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JOURNAL OF THE AMERICAN STATISTICAL ASSOCIATION

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WARTIME DEVELOPMENTS IN AGRICULTURAL STATISTICS

By H. R. Tolley and Conrad Taeuber
Bureau of Agricultural Economics

Wartime food requirements were one of the major factors which led to the establishment of the Department of Agriculture in 1862 and to the beginning of its current crop reporting system. The first Commissioner of Agriculture was charged with the development of current reports on crops and their condition, and set out immediately to expand and strengthen the work in this field. One of his first acts was the employment of a statistician to assist in this task.[1]

Interest in crop production and crop conditions has been widespread from that time forward and the sytem of collecting and preparing reports has grown steadily. When World War I brought the establishment of a Food Administration and other agencies to handle the many new problems created by the war, the crop reporting service provided an existing organization that was able to supply a part of the needed information. But the needs far outran the available statistics, and many devices were developed to obtain and analyze reported data and present the information.

A realization that some of the problems which had been brought into focus by the war would not disappear with the ending of hostilities led to careful consideration of what ought to be continued. It was not enough to collect data; there was a great need for analysis and for application to the economic and social problems in agriculture. The establishment of the Bureau of Agricultural Economics was a step in the direction of capitalizing on the gains that had been made in techniques for solving problems that call for quick and accurate information and competent analysis.

The post-war agricultural depression brought forth many proposals for government aid to agriculture. Both proponents and opponents

[1] *A History of Agricultural Experimentation and Research in the United States, 1607–1925.* Alfred Charles True, Misc. Pub. 251, U. S. Department of Agriculture, June 1937, p. 45.

lacked current and reliable information; consequently there was much pressure to expand and modify existing series and to develop new ones. This offered an opportunity to apply modern statistical techniques, and many of the developments of that period became the foundations of current statistical series. Later, when the action programs of the 1930's were developed, the administrators found a large body of available data and some analysis which helped in outlining problems and problem areas, and served as a guide in the formulation of policies and programs. The new agencies became consumers of data other than those which were readily available and in turn became sources.

With this background of experience, the Department of Agriculture had accumulated a large body of statistics relating to the agriculture of the United States when World War II began. It had also a mechanism which could readily be adapted to meet many of the specialized needs of wartime food management. Therefore, it was unnecessary to develop an entirely new organization for that purpose. Nonetheless, some new series had to be started to fill new administrative needs; some old series had to be expanded; and wider coverage was required in some cases to provide detail, or because of administrative needs for information concerning every potential respondent. There was a rapidly growing demand for information on food distribution and food consumption, which had been developed far less fully than information on production. Much of the demand is still unmet. Some reports were needed more frequently than they had previously been available, and the demand was insistent for data for smaller areas, for a break-down of national figures by regions and states, of state figures by counties, and for areas within counties.

In many cases, refinement of concepts and procedures, greater geographic detail and greater precision would have been desirable. The administrators of the new programs appreciated the need for and the utility of adequate statistical information. The use of data in administrative decisions and action and the consequent demand for high standards of precision were not new, but wartime pressures brought them into sharper focus than had been the case earlier.

Prices.—The demand for information was particularly insistent in connection with the price programs. The parity legislation of the middle thirties had set up a general definition of parity prices and such prices had been calculated for the principal commodities, but the list of commodities was far from complete. Price-support and price-ceiling programs not only required parity prices for virtually all agricultural commodities, but called for much more detailed information than had

been needed for the peacetime programs. It became necessary to establish not only the general level of prices, but also specific price differentials for grade, location, and season. Such data were needed for both support-price and price-control purposes; this involved a considerable volume of additional information.

Government programs in turn affected prices and differentials, and made it even more important that the data correctly reflect the current price movements. At the same time, they increased the problems of data collection, for in the absence of normal relationships there was greater need for measurement of relatively small changes as well as assurance that the reported changes reflected actual changes and not primarily fluctuations resulting from sampling. The collection of price data for programs of administered prices has had to cope with additional problems in order that the reported prices might reflect accurately the movement of prices actually received by sellers. For some commodities there were large-scale dislocations of markets, which sometimes resulted in prices that varied considerably from those prevailing in the established markets. Some commodities that may pass directly from producer to consumer without going through other market channels were particularly subject to the operation of black markets. The influence of such transactions on the price level cannot be disregarded, but having them properly reported is difficult.

Prices farmers pay is the divisor used to determine whether the index of prices received is approaching or departing from the levels that assure parity. The problems encountered in estimating prices farmers pay have been similar to those met in constructing the cost-of-living index of the Bureau of Labor Statistics: The disappearance of certain items which formerly were purchased in large numbers, and the shifting importance of certain items as shortages developed, black-market operations, tie-in sales, hidden price increases, a substitution of higher-priced packaged goods for lower-priced bulk goods formerly purchased, population shifts, etc.

Attention has recently been called to the fact that the index of prices paid by farmers for consumption goods rose by 45 per cent from December 1940 to March 1944, whereas the cost-of-living index of the Bureau of Labor Statistics increased only 23 per cent during the same time. A careful analysis of the items covered by the two indexes—the effect of differences in population weighting to allow for the fact that half the rural population lives in the South; the effect of including rent and services in the one index, and their absence from the other; as well as of other differences in basic concepts—has shown that the movement

of the two indexes has been remarkably close for those items that are comparable.

Farm income.—Farm income statistics, both gross and net, are estimated by years beginning with 1910; net farm incomes have been estimated annually by states since 1940. But there is need for more detailed information concerning farmers' incomes, their receipts, and operating expenses. These are needed by type of farm as a basis for ceiling and support prices. The lack of comprehensive data relating to distribution of incomes by size has been a serious handicap in the analysis of the effects of a number of programs. The extent to which farm families are dependent entirely on their farm incomes or typically supplement them by income from nonfarm employment has been a controversial question in much of the discussion of agricultural policy. The data to settle this question are not now available, but there is some prospect that they may be obtained in the near future.

Agricultural production.—The need for production statistics for wartime agricultural programs has been met largely through the series that had been developed earlier. Some reductions were made during the defense period, when all activities were under scrutiny to find what might be eliminated "for the duration." It soon became apparent that this was not the field in which to cut, for data that had been useful in peacetime became vital in wartime. Although the frequency and detail of some publications were somewhat reduced, and some were eliminated entirely, in general there was an increased demand for production data. Time and again the existing machinery for collection of data and the basic data that had been collected in the past were pressed into service to supply some emergency need. The farmers who, as volunteer crop reporters, provide the basic link in the machinery for collecting production data, were quick to sense that facts are weapons of war, and were willing to do their share, even though it meant special questionnaires or additions to questionnaires already long.

A major gap in the current production statistics is that relating to the production of vegetables in home gardens and in commercial market gardens from which about all of the product is moved by truck to nearby cities. The increase in the number of home gardens made it especially desirable to obtain information about that segment of production for which it had not been possible previously to develop satisfactory statistics. The highly specialized field of vegetable production has always been one of major difficulty, for sampling there is unusually difficult. A number of agencies attempted surveys of production in home gardens and home canning, but on the whole these were not suc-

cessful. A sample enumeration in the fall of 1944 is expected to provide more adequate statistics than those hitherto available and, it is hoped, will make it unnecessary to continue the use of some of the crude estimates which have served in lieu of facts in this field.

Distribution.—Although agriculture in the United States has broken all previous production records during the last eight seasons, there has not been enough food to provide all possible claimants with all they were ready to buy. The management of food supplies to assure equitable distribution to and among the claimants, whether Armed Forces or civilians, and whether domestic or foreign, has shown the need for new statistics on distribution. It was necessary to expand the data on position of stocks of a variety of commodities and to develop data for other commodities. Data showing the movement of commodities through trade channels became essential, if critical supplies were to be used adequately. Such information obviously was needed for the vast supplies which were purchased by Federal agencies, but in many cases information concerning those supplies which were moving through private trade channels was also needed. The collection of data by the Office of Price Administration built up a new body of information on movement through wholesale and retail channels.

The administration of price-control programs calls for elaborate data showing prices of farm products and their derivatives at all levels of the marketing process. The existing series on the proportion of the food dollar which goes to the farmer provided far less detail than was needed. A large body of information has been collected, including comprehensive audits of firms representative of a number of branches of the food trades. These data were collected to meet immediate administrative needs; but, together with other information becoming available, they can serve to open up new areas for analysis.

The need for sharpening concepts and definitions which arose out of the administrative use of data is illustrated in the statistics that show the proportion of the consumer's income spent for food. A variety of measures for different purposes are available: (1) the proportion of total income actually spent for food, (2) the proportion of comsumption expenditures which went for food, and (3) the proportion of income or expenditures required to purchase a "market basket" of relatively fixed content. The first of these measures has gone up rapidly, reflecting increases in food prices, increases in the quality and quantity of food purchased, increases in the number of meals eaten out, increased expenditures for liquor, and other changes in food-buying habits. The second reflects all these elements, plus the effect of the unavailability of some

comsumer's goods. The third reflects the changes which are due solely to changes in prices of foods, and does not reflect changes in consumption and buying habits. Each of the three serves a useful purpose. Drawing them into the forum of policy debate and action revealed a need for reexamination and some revisions. Although the changes which actually resulted were minor, more confidence can be placed in the figures which resulted from the process.

Processing.—Food processing had not been of major concern in the activities of the Department of Agriculture before the war, and relatively few statistical series had been developed in this field. Data relating to manufactured dairy products were one of the few exceptions—the Department, in cooperation with state agencies, had developed a comprehensive series of information on this subject. As control and subsidy programs were developed it became apparent that the existing system could be used as a nucleus for collecting the expanded data which were required. The needs of the Office of Price Administration, War Food Administration, Defense Supplies Corporation and the Bureau of Agricultural Economics are being served through a consolidated reporting procedure under which the reports required by these agencies are shipped to one office, where they are jointly processed. The saving to respondents as well as to the government is obvious.

In some other situations such an expansion of existing organization and procedures was not possible. The War Food Administration needed a variety of information about fields that were largely unknown. In a few instances so little current information was available that the office charged with the administration of an order was unable to make an accurate advance estimate of the number of firms involved, or of the proportion of the product which came from the several parts of the industry. Current reports were developed to reflect current operations, and, in many instances, reports for a designated base period were collected in order to provide a basis for administration of an order within the framework of existing relationships in the industry. In conformity with policies laid down by the Bureau of the Budget, reporting by the smaller firms, which account for only a fraction of the industry's output, has generally been curtailed, either as to content or frequency or both.

There is little doubt that some of the new series which have been developed in response to wartime needs will continue to be needed in the administration of peacetime programs. Statistics of livestock slaughter are a case in point. Before the war, much of the current data on this subject were byproducts of the reports by the Federal Livestock

Inspection Service. Wartime meat controls have expanded the number of plants under Federal Inspection, and have also called for reports from other segments of industry. As a result there has been developed a more complete statistical picture of that industry than had been available before. This volume of information should serve as a basis for developing a more adequate system of current reporting than has been available heretofore, and provide a basis for sampling which would not have been possible otherwise. Moreover, the data collected from the smaller commercial slaughterers and from certain farm slaughterers provided information relating to one segment of the industry about which little had been known previously.

Food consumption.—Data relating to food consumption became one of the major needs, and the lack of adequate information in this field was one of the major gaps in the data which were available. The distribution of food among all population groups under rationing, a comparison of foods actually consumed with nutritional requirements, and a comparison of food consumption in the United States and in the countries receiving food through Lend Lease posed problems for which no easy solution was available. The use of figures showing the disappearance of foodstuffs in total or per capita soon proved inadequate to the needs of the situation. Such totals or averages fail to reveal how the food is distributed within a population and whether certain groups are far above or below the average. In Great Britain a periodic survey of actual food consumption among the several population groups was carried on as an essential part of the food-management problem. No similar information about food consumption was collected directly from a sample of families in this country. One small sample investigation was made as part of the Study of Spending and Saving in Wartime. Because such data would have provided valuable assistance in food management, a number of other surveys of consumption, and of savings and expenditures were planned, but the necessary approval and funds were not forthcoming. The need for more current information about food consumption as such remains largely unfilled. There is also an urgent need for better units of comparison of nutritive levels. They are needed for comparisons of geographic and other groupings in this country and for comparisons among countries. A recent study compares the situation in Great Britain, Canada and the United States and clearly illustrates the needs and the shortcomings in present data.[2]

In large measure the problem of developing food statistics as such is

[2] *Food Consumption Levels in the United States, Canada, and the United Kingdom.* Report of a special Joint Committee set up by the Combined Food Boards, U. S. Department of Agriculture and War Food Administration, April 1944. 121 pp.

the problem of shifting the emphasis from agricultural production as such to agricultural production in relation to food needs. The volume of agricultural production and the volume of available food supplies are not necessarily identical, nor does an adequate total supply of food assure adequate supplies to all economic and social groups in the population. But the realization that this is so is largely a development of recent years. The units and techniques for current measures of food consumption in part remain to be developed.

Feed.—The development of programs for increased production of livestock and livestock products called for more complete data on feed and feed supplies than had previously been available. For example, there was need for more complete information as to production, distribution, and utilization of oilseed meal and other manufactured feed. Data showing utilization of feed supplies by different types of livestock are needed to improve estimates of the livestock-feed balance and to enable more adequate planning for utilization of supplies. As the distribution of feed became a major activity of the War Food Administration, data showing interstate movements of farm-grown and manufactured feeds became particularly important. Steps were taken to obtain such information for most of the manufactured and byproduct feeds for the year 1942, and data relating to the interstate movements of oilseed meal are being collected currently as a part of the administration of the set-aside programs for such meal. There has also been some expansion in the information being collected about some other feeds, such as tankage and meat scraps, fish meal, byproduct feeds, etc.

Farm labor and farm population.—It became apparent early in the National Defense Period that surpluses of farm labor which had been general throughout much of the preceding decade might disappear very rapidly and that stringencies in the farm labor situation were likely to develop. The farm labor statistics collected then were not adequate to meet anticipated needs, and, therefore, plans for expansion and improvement of these statistics were prepared. But, except for a short-term expansion, the necessary authorization and funds did not become available. Some improvements, particularly in the wage-rate data, however, have been made, including the collection of wage rates for specific operations, such as cotton picking, orange picking, blocking and thinning beets, etc. The growth of the monthly enumerative sample counts of employment and unemployment by the Census has provided some additional information on agricultural employment, and has served in turn to raise questions of definition and coverage. The Census series is based on individual reports; the Bureau of Agricultural

Economics series is based on establishment reporting; and differences between these two methods of reporting called for careful investigation.

The effect of other differences also required analysis:

(1) A person who works part-time in agriculture, while devoting the major portion of his time to a nonagricultural activity is reported as a nonagricultural worker in the Census series, but if he works more than the specified minimum time at agriculture, his contribution is counted in the Bureau of Agricultural Economics series;
(2) The Bureau of Agricultural Economics series specifies a minimum of two days' work in the sample week and the Census has no such minimum requirement;
(3) The difficulty of objectively defining the concept of unpaid family workers and consequently of enumerating such workers.

In cooperation with the Bureau of the Census a survey was undertaken in April 1944, embodying an attempt to clarify some of these problems, and including an experimental approach to an objective classification of unpaid family workers. Although the results have not yet been completely analyzed, they indicate the way to better data.

Drawing large numbers of unusual workers into the agricultural labor force has introduced some new problems in the reporting of farm labor, but at the same time it has created a need for more adequate information on this development. One survey, undertaken in cooperation with the Bureau of the Census, provided information showing the total number of persons who worked in agriculture during the year, and their time inputs. It found that in 1943, when agricultural employment varied from a low of 8.2 million in January to a high of 11.9 million in October, a total of 14.5 million different persons worked some time in agriculture. Such information provides a much more adequate guide to the size of the recruiting problem than does the net difference between the seasonal high and the seasonal low, which were the best data previously available.

Estimates of changes in the farm labor supply have been in constant demand, but they have proved much more difficult than have estimates of the number of persons actually working in agriculture. Because the bulk of farm workers at any one time are farm residents, these demands called for development of farm population figures. Early returns from the 1940 Census had indicated that the concept of farm population—defined as all persons living on farms—was no longer the useful analytical tool it had been when it was first given Census recognition a quarter of a century ago. A large number of persons living on farms are not engaged in agriculture, and, conversely, a large number of persons en-

gaged primarily in agriculture do not live on farms. Defining a farm so that enumerators could readily recognize an establishment as being or not being a farm had become more difficult as a result of the growth of part-time farming, suburban living on relatively large tracts of land, the development of transportation and other equipment which reduced the need for the operator's living on the farm, and the growing number of persons using farms as places of residence, whether or not they were directly associated with the agricultural enterprise. Differences in coverage of the Censuses of Population and Agriculture were carried forward in current estimates, which necessarily took the basic Census figures as the point of departure. Analyses in progress have not yet provided a conclusive guide to future practices and definitions, but are resulting in clarification of concepts and in more usable data.

Public opinions and attitudes.—A major expansion into a new subject matter field for the Bureau of Agricultural Economics was the development of the work in public opinions and attitudes. This work started on a small scale in the Agricultural Adjustment Agency in 1936, when the administrators of that Agency felt the need for greater knowledge of the public attitudes toward their program and the way in which it was operated. The service proved so useful that in 1939 more systematic development was decided upon and thus an organization was ready to meet the wartime needs of administrative agencies for such data. Program administrators needed to know quickly how a program was being received by the people most affected and by the public at large. They needed to know also the reasons for success or failure, and to get suggestions for possible improvements which might be used in that or in similar programs to be developed later. The interpretation which people placed on the provisions of a program and its restrictive or benefit features, and the ostensible or real reasons for the actions they took were of vital concern to administrators of fast-moving programs. Many of the wartime activities were along new lines and past experience provided little guidance. To carry them out successfully required a quick and reliable means of telling administrators how people reacted to these wartime activities and programs. Attitude and opinion surveys provided one of the means of obtaining such information, and they were increasingly in demand. They were used to interpret reports on Farmers' Intentions to Plant, and obtain information as to views of farmers on price-support programs, on the corn-purchase programs, on proposals for marketing livestock at lighter weights, on rising land values and on other subjects.

Other surveys included responses to the "Clean Plate Club" cam-

paign, other nutritional campaigns, the potato storage campaign in 1943, the response of housewives to dehydrated foods, and others. The studies of attitudes and opinions were undertaken primarily for administrative use. When the results can be made available for wider use, they should provide valuable sources for studies of changing attitudes toward farm problems and for rural-urban differences in information about and attitudes toward farm problems and programs.

COOPERATION WITH OTHER AGENCIES

Since the beginning of the war there has been a noticeable increase both within and without the Department in the recognition of the close relationship of agriculture to other parts of the national economy. A number of the control programs were carried out through close working relationships with other agencies, especially the War Production Board, the Office of Price Administration, the War Manpower Commission, etc. This in turn has had its effect in the statistical work done in the Department, for there were frequent instances in which it was more necessary than before that the data for agriculture and for other parts of the economy be directly comparable; for example, problems of labor supply and demand, of wage rates, and workers' incomes. Statistics on dairy production were developed as a joint effort by the Bureau of Agricultural Economics, the War Food Administration, the Office of Price Administration, and the Defense Supplies Corporation. Statistics on lumber and forest products were developed as a joint undertaking by the Forest Service, the War Production Board, and the Bureau of the Census. Statistics on fats and oils became a joint undertaking by the War Food Administration and the Bureau of the Census with close relationships with the War Production Board. Statistics on stocks of soy beans, wheat, and other grains collected by the Bureau of the Census, the Bureau of Agricultural Economics, and the War Food Administration are now more effectively combined into reports on total stocks. Data on food costs and other living costs are of concern to the Bureau of Agricultural Economics, the Bureau of Human Nutrition and Home Economics, and the Bureau of Labor Statistics and there has been an increase in joint study of the problems encountered in collection and analysis of such data and of the comparability of the resulting series. Close cooperation was developed between the Bureau of Agricultural Economics and the Bureau of the Census to work out problems of estimating farm population and changes in the farm population. The new needs of the War Manpower Commission, the Bureau of Labor Statistics, and other agencies for data on farm population and

farm employment called for some reorientation in the previously available series.

A significant development in closer cooperation with agencies outside the Department of Agriculture was the establishment of a joint Agriculture-Census Committee for the planning of the 1945 Census of Agriculture. Carrying forward a long-standing tradition of cooperative planning of censuses of agriculture, the new arrangement provided for a committee with representatives of both agencies which had responsibility for developing plans for schedules and tabulation. As a result of the efforts of this committee, it is believed that the forthcoming Census of Agriculture will provide data more useful to agriculture than those that were previously available. It is also anticipated that the quality of the enumeration will be improved as a result of the cooperation between Census enumerators and representatives of agricultural agencies in the field.

SAMPLING TECHNIQUES

The need for quick surveys providing reliable information for a representative cross section of the entire United States, regions, states or other areas focussed attention on sampling procedures and field enumerations. Moreover, it has been increasingly apparent that the conduct of numerous field surveys, each using its own sampling procedures, made for lack of comparability of results, and, consequently, for inefficiency in the conduct of such surveys. Therefore, work was undertaken to develop some uniform and integrated sampling scheme for surveys in rural areas. It was decided to develop a sample of farms which in effect would be a small replica of all farms in the United States. This sample is designated the "Master Sample." It consists of a sample of small geographic areas including a total of approximately 300,000 farms. It is subdivided into three independent national samples, each comtaining approximately 100,000 farms, which can be used separately or combined. Subsampling is also provided for. Moreover, the work has been done in such a way that additional samples can readily be drawn as needed. Farms in every county in the country which contain agricultural enterprises are included in the sample.

In each county, the entire area was divided into small areas consisting of clusters of about 5 farms each. These small areas are defined in such a way as to be bounded by political boundaries, by roads or other physical characteristics insofar as possible, because it is essential to the scheme that boundaries be readily identified by the enumerators in the field. Aerial photographs for most of the sample areas

are available and are proving of assistance in locating boundaries where they are not readily identifiable in the field from maps. Within each county, three samples, each consisting of approximately one-fifty-fourth of the small areas as defined, were drawn in such a way as to represent all parts of the county. With the boundaries of the sample areas established, a set of rules has been developed for the purpose of associating each farm with one and only one sample area.

The work of drawing the sample has been done cooperatively by the Bureau of Agricultural Economics and the Bureau of the Census, using the facilities of the Statistical Laboratory maintained by the Department of Agriculture and the Iowa State College. As part of the forthcoming Census of Agriculture, a supplemental set of questions is to be taken from each of the farms in the Master Sample areas. This will provide for more information than could be obtained if it were necessary to ask all questions of all respondents. Present Census plans also call for some preliminary tabulations from the main schedule with the use of this sample for early release. Satisfactory state estimates can be prepared for most items through the use of this sample.

As each farm enumerated by the Census will be associated with the appropriate sample area, tabulations can be made which will provide information as to the items covered by the Census for the sample areas as such, or for any specified combination of the sample areas. This should provide more adequate background information for subsequent surveys and will also provide a basis for more efficient subsampling to meet the special objectives of particular field surveys.

This area approach to sampling is useful for other than agricultural purposes. A sample designed primarily for population and related enumerations is now being drawn for incorporated places and for "thickly settled" unincorporated areas where nonfarm and farm populations are intermingled. This, like the work for farming areas, is being done cooperatively by the Bureau of Agricultural Economics, the Bureau of the Census, and Iowa State College.

The Master Sample has already demonstrated its utility in small-scale field enumerations, both National and state-wide. Its major usefulness will be in its applicability to field surveys. Because it provides an efficient sampling tool, it is expected to stimulate better sampling in field surveys. But the use of the Master Sample is not limited to its use in field enumerations. Experiments have been carried on to test the possibility of combining the use of the Master Sample with mailed inquiries. Because the characteristics of the population in the sample areas can be known, it is possible to correct for a large part of the bias

which frequently develops in mailed inquiries. A comparison of the characteristics of the persons who responded to the mailed inquiry, with a similar tabulation of the characteristics of all respondents to whom the inquiry was sent, provides a means of knowing whether the returns actually received are representative of the entire universe or only of that portion which supplied information. In this way the use of the Master Sample promises not only to improve field enumerations but also to improve the results from mailed inquiries.

Another possibility lies in the combination of mailed inquiries and field enumeration, using the field enumeration to fill in the gaps which the mailed inquiry leaves. A similar technique has been used with good results in a survey of sawmills. There, the sample was selected from a pre-listing of all sawmills. The mailed questionnaire was used in order to reduce the cost of the collection of data, and a sample of the firms that did not report by mail and those sending inadequate reports were subsequently visited by a field enumerator.

However, the major advantage of this sampling device lies in its use in connection with field enumerations. Sampling designs can be prepared more effectively and a number of designs can be used which would be impossible without the Master Sample. If for any reason field work for a survey is not entirely completed, the portion which is obtained can be evaluated more readily than would be the case if the characteristics of the total sample were not known. The information obtained by each new survey adds to the knowledge of the farms in the Master Sample. As the sample land areas are clearly defined, changes in number of farms, ownership, size of farm and farming conditions, changes in farm population, and similar changes can be estimated independently of other data. Consequently, the Master Sample will not become out of date, but will reflect changing conditions in agriculture.

The development of the Master Sample opens a new field in the collection of agricultural data, but also opens a large new field of research in sampling problems. Because it provides a great increase in sampling efficiency over current methods, it will provide the same information with smaller samples than are now feasible, or greater precision for a sample of given size. Further improvements in sample design and improvements in techniques for subsampling are to be expected as this tool for research is developed and as it is used in the field.

Many inquiries are necessarily limited to a sample much smaller than the total number of farms in the Master Sample because of limitations of funds and personnel or because of the nature of the problems with which they deal. In many instances these smaller samples are best de-

veloped by selecting a sample of counties and enumerating all farms in the Master Sample Areas within them. A number of techniques for selection of sample counties are being used and studied. In one recent instance, the techniques of component analysis have been applied to this problem with what promises to be highly useful results. The problem, in one case, was to design a sample of approximately 70 counties which would represent the major type of farming areas. It was desired to salvage as much as possible of a smaller sample which had been selected earlier for related work, and to provide maximum freedom of choice for the field workers who were in close contact with representatives of the state colleges of agriculture. Through the use of component analysis a scheme for stratification was devised, which provided for control of the major relevant factors and also met the practical considerations of the situation. The field workers were given freedom to choose within the sub-strata; the results of their selection were then tested for bias; and subsequent adjustments in the county selection were made as required. The full possibilities of this technique for selecting sample areas for many types of inquiry remain to be explored, but the experience to date warrants considerable optimism for its continued utility.

THE OUTLOOK

Food and agriculture are likely to continue to be subjects of Government programs and public concern. Therefore, demand for statistics as guides for action will continue as a basis for checking on action already taken, and as a basis for understanding past, current, and prospective developments. A major reconversion problem for agricultural statistics lies in finding ways and means of utilizing the gains that have been made in (1) the development of more adequate statistics in some fields, (2) providing more substantial bases for many of the estimates which were made under wartime pressure, on subjects for which information will continue to be needed, and (3) the development of statistics in essentially new fields. When War Food Orders and similar controls calling for reports from every person affected, are relaxed, the need for information in many instances can be fulfilled through returns from a sample of the respondents. Current compulsory reports with nearly complete coverage also provide a basis for selecting more efficient samples than has been possible heretofore. Developing information on food processing and the movement of food through the several channels from producer to consumer may be easier in the future because there is a growing awareness of the utility of central collection of statistics.

Although early in the war there was considerable opposition to the numerous questionnaires called for by government agencies, many business establishments have recognized the utility of the data being collected. Through the efforts of the Bureau of the Budget, in cooperation with agencies originating inquiries to the public, much of the unfavorable reaction has given way to an understanding of the needs for and the ways of using the data collected. At present the Bureau of Agricultural Economics is unable to meet all of the requests for information and for the establishment of statistical series which originate with business interests.

Wartime developments in agricultural statistics involved gains as well as losses. Existing techniques for the collection of data have been further developed to meet wartime needs and, in some instances, new techniques have been devised. The growth of the use of sample enumerations, utilizing small samples to obtain unbiased results at relatively little expense is a development which undoubtedly will continue to be of major importance. It is probable that in the collection of agricultural data in the future less reliance will be placed on mailed questionnaires and more on sample field enumerations, and that ways will be developed for increasing the efficiency of each of these techniques. Only a small beginning has been made in the exploration of possibilities of combining the advantages of these two techniques.

There is a growing need to investigate the techniques for collection of data. Little is known about the interaction between interviewer and respondent and the conditions which make for accurate or inaccurate responses. Some investigations in connection with public opinion and attitude surveys have revealed the possibilities of direct or indirect influence of the interviewer on the response, but this field needs further exploration. It is known that in the collection of quantitative data, certain biases are likely to enter. For example, income or value of product is frequently understated. The assumption that an interviewer who is familiar with the subject matter assures adequate responses from most respondents needs further testing, and much more research is needed on the process by which information can be most effectively obtained.

Selecting individual respondents is one aspect of sampling as practiced in connection with agricultural surveys which needs more attention. The Master Sample provides one means for eliminating much of the bias present in most current methods used in selecting the individual respondent. Other devices can no doubt be developed to fit the various field situations which arise.

There is need also for developing ways of reducing the volume of in-

formation which must come from any one respondent if the necessary information is to be obtained with the required degree of accuracy. Recent developments in sampling suggest that there are ways in which samples of respondents can be matched for the relevant control characteristics and parts of the total volume of information secured from each in such a way that over-all figures can be developed from these samples. There is need also for the development of techniques for use in sampling within the volume of data ordinarily considered necessary in surveys involving consumption, expenditures, and other fields of behavior.

Until relatively recently, developments in techniques for analysis of statistical data have outrun techniques for collection of such data. This is a gap which should be and is being closed. The application of some of the work in design of experiments for biological research to that in economic and social research has opened up new techniques for data collection. During and shortly after World War I, the demand for all kinds of data grew rapidly. In many cases information was collected without much thought of its ultimate use. Some of the collection of data done recently under the pressure of wartime needs has been disappointing to the responsible administrative agencies, chiefly because the techniques used in collection were not such as to permit adequate utilization of the data once they were assembled. There is a need for continued development of a critical approach to the collection of data as a useful tool and for parallel recognition that in unskilled hands this tool is inefficient and possibly dangerous, and that very frequently the results may be misleading.

As more adequate national data are developed, demand for the development of similar materials for smaller areas is persistent. Many of the data that are now being collected are needed for relatively small and homogeneous production areas. State and county estimates are in constant demand, but at present this demand can be met only in part. Periodic sample enumerations would go far in meeting such demands. They would also relieve the pressure on the quinquennial and decennial censuses of agriculture, which are now the major source of data for small areas. It may well be that other techniques can be developed to meet these local needs which arise largely out of demands for action.

INSURANCE IN THE INTERNATIONAL BALANCES OF PAYMENTS

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I

It is the basic principle of insurance to spread risks in space and time as widely as possible in order to bring into play the law of averages. The distribution and compensation of risks beyond the political boundaries of the home country is thus inherent in the very nature of insurance. There is marked distinction between the urge to export goods and the need for international insurance cooperation. In case of insurance, though the companies are of course looking for profits, it is not primarily a question of increasing the turnover, it is first and foremost a technical necessity, the fundamental need to broaden the basis of risks in order to produce stability and equilibrium in the business.

The spreading of risks beyond the political frontiers of the home country can in principle be achieved by three means: (i) direct insurance operations in foreign countries, (ii) affiliation of foreign insurance companies, and (iii) reinsurance. And indeed before World War I international insurance business kept pace with the development of international trade and commerce and became an important factor in world economy. Along the highways of international commerce the insurance companies of the great trade nations established branch offices and agencies or founded affiliated national companies, thus spreading and popularizing insurance over the whole world. The tremendous growth during the fifty years before the Great War is due largely to the international activities of the pioneer insurance companies.

This development reached its peak with the Great War, which abruptly interrupted and in many cases reversed international business relations. It is not necessary to review here all those measures of economic warfare which were adopted a quarter of a century ago and which, unfortunately, have had to be re-introduced now—they are generally known. As a result of those measures and subsequent political and economic events, the writing of direct insurance business on an international scale is showing a relative or absolute shrinkage. Countries which not long ago were without national insurance organization have already built up or are building their own insurance markets, in others the growth of the home companies was speedier than that of the foreign companies and the relative position of the two groups had already changed to the disadvantage of the latter. This process of na-

tionalization of direct insurance business was given impetus after the Great War by legal, administrative and economic measures of the Governments, by exchange regulations and other restrictions of international payments, by the transformation of branch offices of foreign companies into domestic enterprises, and so on. Conditions of the present war are carrying the process still further.

To what extent international direct writing insurance business declined between the two wars is illustrated by some figures. In Switzerland the share of the foreign companies in the total home business was 35 per cent, now it is less than 1.5 per cent. In Norway foreign business was 20 per cent and was reduced to 4 per cent before the present war. In Italy 40 per cent of the home business was in the hands of foreign companies which went down to 4.5 per cent between the two wars. In Finland the foreign companies held 12.7 per cent of the life business and 13 per cent of the fire business. Before the outbreak of the present war 100 per cent of the life business and 97 per cent of the fire business was in the hands of home companies. And even in Germany the share of the foreign companies in the home business in the period between the two wars has been reduced from 8 to 3 per cent. These are taken at random where appropriate statistics are available. More striking changes took place in more remote countries lacking statistics.

Reinsurance as a secondary form of international cooperation in insurance has grown very much in recent decades and has greatly increased in importance. In line with direct insurance it expanded in all directions. New systems and methods were devised, more suitable for world-wide activities. Though reinsurance, being practically invisible to the public, does not openly offend the nationalistic sympathies of some communities, it nevertheless could not escape thorough investigations everywhere of its effect on the Balance of Payments. Unfortunately those investigations, both in case of direct insurance business and reinsurance, were mostly based on incomplete statistics and misrepresented figures and, therefore, a brief survey of the methods of investigation and the interpretation of the results of how insurance affects the Balances of Payments may be of general interest.

II

An international Balance of Payments is interpreted here as a statement of all claims and debts arisen in a certain period of time between a given country and the rest of the world. A credit balance indicates a claim, a debit balance, a fresh indebtedness against foreign countries, arising in the period under review. This definition of the Balance of

Payments is not the only possible one. And indeed very important circles interpret it as an itemized account of the payments arising out of the commercial and financial transactions, conducted within a stated period, by the people of one with all the people of other countries.

It is obvious that the two definitions refer to two entirely different accounts. The first refers to an account of international indebtedness, the second to actual payments which have arisen in a certain period of time. In the first the decisive point is whether a fresh indebtedness arose during the period under review, irrespective of whether, in fact, the debt has been transferred to the creditor countries or not. In the second the decisive point is whether actual transfers have been made during the period under review, irrespective of whether the payments relate to new or old debts. The term "Balance of Payments" is used in both senses and it is always important to differentiate.

According to the established practice the Balance of Payments is divided into two main sections: (i) current items, i.e. goods, services and gold, and (ii) capital items. The distinctions have been said to be based upon the length of time they remain in existence. Current items are likely to be fairly constant in trend from year to year, since they reflect the consuming habits and producing capacities of a nation, whereas capital items are likely to fluctuate widely according to business and political conditions and prospects both home and abroad. As a rule, insurance is regarded as "service," as a part of the large and important class of "invisible" exports and imports. There are, however, exceptions to that rule. Canada, for example, finds that "the most desirable place for inclusion of the insurance item in a Balance of Payments statement seems to be among the capital items. The transactions are more akin to capital transactions than to service transactions, as they are normally executed only when a transfer is considered desirable and are not on the same basis as regular income payments. That is they are inclined to be unpredictable and are not, in any sense, analogous to a current income which varies closely with the general condition of trade." Such a view is a logical sequence of the conception of the Balance of Payments as a statement of transfers, but from the point of view of an account of international indebtedness, insurance transactions are certainly trade transactions, though they may be distinctly different from other "services." They are commercial operations *sui generis*. On the other hand, they are certainly linked with some capital transactions, particularly in case of life insurance. Theoretically the capital transactions should be segregated from the insurance transactions proper, the former belonging in the capital section, the latter in the trade section of the Balance of Payments. In the League of

Nations' standard form of the Balance of Payments, insurance is included in the current items and mixed up with commissions and brokerages. In some countries, however, insurance items in their national balances are divided from other transactions, and definite figures are given relating to insurance itself. How those figures are arrived at and how far they are reliable, is of course an open question in each case.

III

The estimation of the so-called invisible exports and imports, including insurance transactions, is admittedly an extraordinarily difficult task. In spite of all sincere efforts to develop reliable general principles upon which such estimates could safely be based, the produced figures remain as a rule more or less questionable approximations. The inquiry into the figures of the insurance business is, however, even more difficult, owing to the particularly complex nature of these transactions.

The mechanical comparison of the premium incomes and payment for losses of foreign companies in a given country on the one hand, and the similar items of the home companies in their business abroad on the other hand, is a method completely unsuitable to give even a vague idea of the problem. As far as the figures are reliable, such a statement would certainly give an idea of the volume of the transactions, but though it may be of some significance it would in no way indicate the profitableness of the business and its influence on the international Balance of Payments of the country. Other items which have to be considered are: interest, expenses, commissions, taxes, depreciations, profits and losses on investments, increase or decrease of the so-called technical reserves (life fund, unearned premiums, unpaid claims, bonus reserve) and any reinsurance taken in the country of origin. In direct writing business through the medium of licensed agencies all these receipts and payments remain in the country of origin. Not before all these items have been properly considered and carefully computed, can a profit or loss of the year's transactions be ascertained, and only such a profit or loss figure could indicate whether a fresh debt had arisen and if so, to what extent and in which direction.

Government insurance statistics are, as a rule, entirely unsuitable for such a computation and statistics of different countries are even less suitable to compare results internationally. It sounds strange, and yet it is true, that insurance business, itself based on statistical experiences, in many countries lacks statistics about the state and development of its own trade. Either no statistics at all are available or else they are very defective. In any case the variations of statistical methods used in different countries recording some facts on insurance make

futile any attempt at international comparison of the results. In some countries the statistics are based on gross figures, in others on net figures. In some the whole business is accounted in total, in others it is divided into sections and branches. In some home and foreign operations, direct and indirect transactions are segregated, in others they are combined. In some countries the presentation of the published accounts is uniform, in others each company chooses the form of presentation itself, with the result that sometimes it is impossible even to gather the most elementary data on a uniform basis.

International direct insurance business through established branch offices or licensed agencies is one, but not the sole, factor in the investigation of international insurance transactions and their effect on the Balance of Payments. The second factor is international reinsurance transactions. In this international trade, too, everything from our point of view depends on the ultimate balance of the accounts. The volume of the business is entirely irrelevant because if the credit and debit items of the reciprocal transactions offset each other, no balance and consequently no international indebtedness is left over, and the transactions are without the slightest effect on the Balance.

There are two more factors to be considered in computing a correct statement of international insurance transactions: (i) unlicensed direct business and (ii) export and import of merchandise on CIF basis.

(i) In most countries insurance transactions with and by foreign companies not specifically licensed for transactions are legally prohibited and penalized. Nevertheless such transactions take place though their volume in most cases cannot be ascertained. It is unlikely, however, that they are of much importance. The very fact that such transactions cannot be based on a regular canvassing organization is likely to make them incidental. As a rule marine insurance and insurance against risks which cannot be covered in the country are exempted from the prohibition, and in those branches a considerable international business is going on, particularly with Lloyd's in London. The extent and geographical distribution of those operations defy, however, all private calculations.

(ii) The question of import and export conditions is from our point of view even more important, although it is not generally credited with the importance it merits. When goods are exported CIF the insurance will be effected by the seller and probably placed with insurers of his own country, insurance premiums being added to the price of the goods and paid for by the foreign buyer. Here again is an indirect form of taking insurance abroad. In spite of the importance of that item it has so

far received no proper attention in the estimates of the effect of insurance transactions on the Balance of Payments, though in some countries (Canada, Finland, France, Venezuela) it has been considered.

It may be clear now that the effect of international insurance transactions on the Balance of Payments of a country is extraordinarily complex, though some casual items (depots, initial cost of organization, etc.) have not been considered in order to avoid further complications.

IV

The problem being as complex as it is, everything depends on the adequacy and reliability of the basic material, on the general principles underlying the collection, computation and compilation of the statement, and upon the judgment and special knowledge of the compiler. The quality of the available statistical material and the qualifications of the compiler are an open question in each case. It is necessary to review some important points.

(1) The first question requiring early decision is whether the statement should be a current account of trade or an account of transfers, or in terms of accountancy should it be a revenue account or a cash account. We interpret here the Balance of Payments as an account of international indebtedness, in marked distinction to an account of transfers, as presented by some countries, whose figures are otherwise computed with admirable skill and competence. The question, what is the final net balance of a country's international insurance transactions, cannot be answered by the medium of an account based on actual transfers, because the time and amount of transfers are in no way in line with the profit or loss of the business. For many years profits from the business may be invested in the country of origin without being transferred or, again, losses may occur and be covered by funds at the disposal of the company in the country in question without actual transfers. On the other hand, a change in investment policy which causes a company to buy or sell securities in another country will result in transfers. For example, the very elaborate investigations in Canada and the United States reveal that the net equities of foreign insurance companies operating in those countries grew permanently in recent decades and they are now considerable indeed. It is very likely that this excess of assets over the liabilities of foreign companies in those countries entirely or partly represents accumulated profits reinvested in the country of origin. On the other hand, examples are not rare where the liabilities of foreign companies are in excess of their assets in the same country, indicating that they transferred some amounts for reasons of

investment policy, which some time have to be re-transferred to meet liabilities. For these reasons the balance of transfers cannot be a suitable medium for approaching the question of international indebtedness caused by insurance transactions.

(2) In some Balances of Payments, insurance figures embrace the transactions of foreign affiliated companies as well—with little justification. Reinsurance relations between the affiliated and mother companies are automatically included in the reinsurance accounts. Other transactions, like payment of dividends or buying shares, have nothing to do with insurance transactions proper. They are investment transactions of foreigners, like any other investments, and belong to the category of capital items.

(3) Very important is the proper consideration of the movement of the technical reserves, particularly in life insurance. It is common knowledge that between the income and expenditure of a going life insurance concern there is a wide gap, since individual life insurance to level premiums is a particular form of long-term saving. The excess of income over expenditure is, however, to a large extent not a profit to the company, but it has to be put aside as a trust amount to meet future liabilities. In most cases those amounts must not be taken out of the country of origin, though there are still a few exceptions to this rule. Obviously these amounts and a few similar items, in trade terms the movement of the insurance funds and technical reserves, have to be treated as expenditures. Should the transfer of such amounts not have been prohibited by law and should such transfers actually take place, the items belong to the category of capital movements and should not be included in trading balances.

(4) The business of a foreign insurance company written in a certain country may be, and as a matter of fact very often is, partly reinsured in the same country. All items regarding such reinsurance transactions are purely internal transactions and do not affect the Balance of Payments, but they do affect the ultimate trade result.

(5) Depreciations, profits and losses on investments and interests have to be considered whether they are connected with the insurance business proper or with the net equity of the company and they are to be treated accordingly as trade or capital items.

V

Though most countries compile and publish Balances of Payments, the insurance business is not always included in the sphere of investigations. Some others, again, do make investigations into the ques-

tion, but do not release the result of their findings or they do that in combination with some more items, like commissions and brokerages. The most elaborate investigations have been made by Canada and the United States. Both estimates are based on the transferred amounts. In some countries private compilations are supplementing official statistics or substituting it altogether.

Great Britain is among the countries combining insurance with commissions, etc., in her Balance of Payments. The yearly income of the country under this heading amounts to £35 to 40 millions of which 10 to 12 millions result from insurance operations overseas. That the question attracted the closest attention of the authorities has been made clear by an article in the *Journal of the Board of Trade*, No. 2213, Vol. 142 of May 5, 1939. Great Britain's insurance relations with the European countries were comparatively not so extensive as generally believed. They might have had a considerable aggregate volume, particularly in reinsurance, but they were based on reciprocity. The bulk of the foreign insurance business comes from the Empire Countries, from the United States and from Latin America. For many years the United States has contributed by far the largest part of the net revenue that the companies derived from abroad. Their American business forms a very large portion of the whole. In the fire branch it provides about 55 per cent of the premiums and in the accident branch about 40 per cent.[1] The remittances of branches and dividends of subsidiaries of British companies in the United States average $20 millions per annum.[2] According to American sources transfers in the last years were even greater.[3]

Switzerland is among the most important countries in international insurance business. Though it is well known that the Federal Insurance Supervising Office has repeatedly investigated the question, no official figures have been revealed. There are many private estimates, however, the most comprehensive of which, by Dr. R. Aeberhard,[4] amounts to 50 million Swissfrancs.

The German official figures show a debit balance of about 20 million Reichsmarks as the net result of the country's international insurance transactions in the last years before the present war. This statement is forthwith incredible and in contradiction to obvious facts. The explanation is that the figures are based on a fragmentary basis, embrac-

[1] *The Economist*, July 20, 1940.

[2] *The Economist*, October 25, 1941.

[3] Investigations of the Finance Division of the Bureau of Foreign and Domestic Commerce, compiled yearly by Dr. August Maffry.

[4] "Versicherungsverkehr," *Zeitschrift für Schweizerische Statistik und Volkswirtschaft*, 1935.

ing only the international direct business as far as they fall under government supervision. The true position is revealed, however, by a private author, E. Adrian.[5] According to that estimate Germany's profit from her international insurance trade was, prior to World War I, nearly 100 million Reichsmarks annually. In post-war time the profits were much lower, but progressively increasing.

No official Balance of Payments has been published in France. There is only a private source, the annually published estimates by M. M. Leonard Rist and Philippe Schwob.[6] They estimated the net credit balance of the international insurance transactions of France and her oversea territories (without Indo-China) at about 80 million Francs. The figures of the official insurance statistics in no way confirm the estimates of the authors and therefore the position is rather obscure. The same applies to Italy, too, a country without published Balances of Payments. The known insurance facts and figures justify, however, the assumption that Italian insurance business with foreign countries was in no case negative and very likely positive. Other European countries making official estimates about the subject are: Finland (Central Statistical Bureau and Bank of Finland), Bulgaria (Bulgarian National Bank and the State Control Office for Insurance) and the former small Baltic states. In all those countries the Balances of Payments are almost unaffected by insurance transactions.

From the overseas countries only the United States, Canada, Australia and Japan give estimates of the insurance transactions in their national Balances of Payments.

The case was very carefully investigated in the United States by Dr. August Maffry,[7] on behalf of the United States Department of Commerce. The methods and results of his investigations have been revealed in a comprehensive study covering the period 1919–1935. The investment aspects of the operations of foreign insurance companies in the United States were set forth in another study.[8] Since 1935 new surveys are made annually by the same compiler and published by the Finance Division of the Bureau of Foreign and Domestic Commerce. The latest publication relates to the year 1939. According to this latest report international insurance transactions affecting the United States

[5] "Das ausländische Versicherungsgeschäft," *Wirtschaftsdienst*, 1936.

Other works dealing with the subject are: *Die deutsche Zahlungsbilanz*, Berlin, 1930, Mittler; Wilhelm Kisskalt, *Privatversicherung und deutsche Zahlungsbilanz*, München, 1934; Robert Hafferberg, *Versicherung im Zahlenspiegel*, Die Bank, 1936/32; Alois Alzheimer, *Die deutschen Versicherungsgesellschaften im Auslande*, Berlin, 1939, Francke & Co.

[6] *Revue d'Economie Politique.*

[7] "Insurance Transactions in the Balance of International Payments of the U. S. 1919–1935," *Trade Information Bulletin*, No. 834.

[8] *Foreign Investments in the United States*, pp. 38–40, U. S. Department of Commerce, 1937.

involved a net movement of funds from the United States to the United Kingdom estimated at $31 millions in 1938 and at $28 millions in 1939. There was a net inflow of funds from Canada in 1938 of $11 millions and a net outflow in 1939 of about the same amount. Insurance transactions with all other foreign countries resulted in a net outflow of $5 millions in 1938 and in a net inflow of $2 millions in 1939. The net ultimate balances of all transactions in the 10 years 1929–1938 are given at: (in $ millions) 1929 +2.6, 1930 +11.3, 1931 +13.4, 1932 +8.1, 1933 −17.6, 1934 −18.8, 1935 −14.5, 1936 −26.8, 1937 +2.7, 1938 −15.6. The net debit balance for the whole period is, therefore, $55.2 millions. These estimates are based on actual transfers and probably rather far from the international indebtedness caused by insurance operations.

Canada's wide international insurance relations were first investigated from our point of view by Professor Viner[9] and later in a more elaborate study by the Dominion Bureau of Statistics.[10] The latter study is based on actual international remittances, too. The net balances of all international insurance transactions are estimated for the 10 year period 1929–1938 as at: (in $ millions) 1929 +19.0, 1930 +9.0, 1931 +34.0, 1932 −1.0, 1933 −1.0, 1934 +3.0, 1935 −18.0, 1936 −26.0, 1937 −10.8, 1938 −22.4. The net debit balance for the whole 10 year period is, therefore, $14.2 millions. As in the case of the United States this amount hardly gives a correct picture of the actual indebtedness of the country from insurance transactions.

Australia's international insurance transactions seem to be permanently negative to the Balance of Payments. The indebtedness caused by these transactions are estimated by the Commonwealth Statistician at about £1 million annually for the last ten years.

In Japan's official Balances of Payments an annual credit balance is estimated resulting from international insurance transactions, amounting to about 10 million Yens annually. As that amount roughly coincides with the debit balance of insurance transactions in Manchukuo's Balances it can hardly be regarded as an international item.

VI

To summarize, in no single country has an account been made according to our considerations. The different estimates differ considerably in method and merit and the available statistics are in most cases definitely inadequate. We are bound, therefore, to approach all figures

[9] *Canada's Balance of International Indebtedness, 1900–1913*, Harvard University Press, 1924.

[10] *The Canadian Balance of International Payments. A Study of Methods and Results*, Ottawa, 1939.

with caution and not to take them at their face value without critical examination. Anyhow, some obvious conclusions could be drawn without the risk of gross mistakes. These are:

(1) There are only a few countries the trend of whose international insurance transactions shows a distinct character. There is hardly any doubt that to Great Britain, Switzerland, Germany, and probably to France and Italy, insurance transactions are a permanent source of income from abroad, and on the other hand there are a few countries with permanently adverse balances. In most cases, however, the effect of the insurance business on the Balance of Payments is problematical and fluctuates widely from year to year both geographically and in amount. The period of the observation is in most cases too short and does not allow a definite judgment until the results of a longer period are available. Insurance has to spread the risks not only in space but in time also. All operations from the insurers' point of view are long-term operations, covering good years and bad ones and therefore the isolated consideration of some few years is a mistake in principle.

(2) Available statistics, which cannot be quoted here in detail, show that though the volume of direct insurance business is still a huge one, it is constantly decreasing, particularly in life insurance, and its effect on the Balances of Payments is diminishing alike. In any case the net result of the business is out of all proportion to its volume, and its importance to the Balance is in most cases grossly exaggerated.

(3) In reinsurance its international nature is a strong factor. But the post-war situation changed the situation in this respect as well. In the times before World War I reinsurance was for the most part the business of the professional reinsurers, established chiefly in the Central European countries. That does not mean of course that no direct writing companies accepted reinsurance business, but as a rule there was a distinct division between the business of insurers and reinsurers. The situation is quite different now. Direct insurance companies are very much interested in reinsurance and to some extent the professional reinsurers lost their hold on the business. They had to be content with sharing the business with direct offices and with adjusting their methods to the system of reciprocity which in gradual stages came into general use. The effect of this development from our point of view is that relations are bilateral now and compensating forces are at work to some extent. A onesided swing of the pendulum for any length of time is, therefore, unlikely. A further development of the inter-war period is the establishment of government reinsurance offices in some countries, namely in Turkey, Greece, Chile, Brazil, with the effect of diminishing the volume of that international trade considerably.

MEASUREMENT OF INDUSTRIAL PRODUCTION SINCE 1939

By Frank R. Garfield*
Board of Governors, Federal Reserve System

During the war years some of the usual differences of opinion about measurement of economic affairs have faded into the background. Everyone agrees there is now little unemployment. Meanwhile, certain other differences have been highlighted. Argument about the official cost of living index has been unprecedented and there has been more discussion than usual about the way industrial production is measured by the Federal Reserve Board's index.[1]

This highlighting of technical issues in certain fields reflects largely the fact that in a period of great change, decisions on technical matters are more debatable and make more difference than usual. It also reflects special concern about the social implications of levels indicated by particular indexes. Some observers suggest, for example, that if the index of industrial production is too high for the war years, people may be led to expect a volume of output after the war which would be quite unrealistic in view of the record of the past. Others note that if production figures are too low, current profits per unit of output may appear larger than they really are. Also, if production figures are far out of line in either direction, wage negotiations may be prejudiced.

Considering the unusual developments of the war period, index makers must reexamine their concepts, data, and techniques more often than usual and when they do they are likely to find important revisions required. In October 1943 a substantial upward revision was made in the Board's index of industrial production and since then many people have asked whether it might be too high, especially in 1942; but some think the index may still have a downward bias, particularly during the past year. From further information and study it appears that a few series, such as "other chemical products," are now too high but that some others, like aircraft and tobacco products, are too low. Any further

* This article is based largely on a paper presented at the Joint Regional Meeting of the American Statistical Association and the Institute of Mathematical Statistics, Washington, D. C., May 6, 1944.

[1] See: Clayton Gehman and Frank R. Garfield, "Revision of Industrial Production Index," *Federal Reserve Bulletin*, October 1943, pp. 940–952; *Survey of Current Business*, October 1943, pp. 6–8; *Business Week*, November 6, 1943, p. 112; *London Economist*, January 22, 1944, p. 111; *Cleveland Trust Bulletin*, February 15, 1944, p. 4; Geoffrey H. Moore, *Production of Industrial Materials in World Wars I and II*, National Bureau of Economic Research, Occasional Paper No. 18, March 1944; *New York Times* April 17, 1944, p. 22, May 4, 1944, p. 18, and May 22, 1944, p. 18; Irving H. Siegel, "The Concept of Productive Activity," this Journal, June 1944, pp. 218–228; Geoffrey H. Moore, "Measurement of Industrial Production in War and Peace," this Journal, September 1944, pp. 335–344.

revision, using the same general methods as heretofore, may well raise the index during 1943 and 1944.

The purpose of this discussion, however, is primarily to explore the effects of wartime changes on measurement of production. Changes, both in product and in process, have been much more rapid than in peacetime and have greatly complicated the problem of representing production in a particular industry by any single measure; in fact, they have made it difficult to maintain continuity in the definition of an industry. Moreover, new ways of doing things have altered somewhat the relative weights appropriate to particular activities, with changes during two or three years in some lines comparable to those of a decade in peacetime. Very practical questions arise as to how much these wartime changes have affected the index and how far adjustments have been made to take account of them. Are the various indexes for individual industries, groups, and the total approximately right, accurate enough to use in analysis and to publish?

Mr. Moore suggests that changes in products have been so drastic in some important lines that comparisons of output in these lines before the war and during the war are impossible and that, therefore, such comparisons for total industrial production cannot be satisfactory and should not be attempted.[2] Brigadier General Ayres doubts that there has been any such increase in the amount of fabrication per unit of material as he figures the Board's index implies.[3] Both of these critics attribute the vagaries of the index as they see them to the use of man-hour data, with certain adjustments, to measure fabrication of many finished products. On the other hand, the United Steel Workers of America challenge the Board's index of steel production on the ground that the particular physical measures used there (steel ingots, open hearth and electric) failed to reflect fully the rise resulting from increased finishing of steel ingots and the production of special steels.[4] Mr. Kuznets has raised some questions about the weights used and in a recent paper on gross national product has used a basically different weighting standard, reducing the importance of munitions and war construction considerably.[5] At the same time, Mr. Kuznets thinks that some of the series used in the Board's index understate the rise in output they are represented as measuring.

There are, then, a number of questions about the concepts, data, and

[2] Geoffrey H. Moore, *op. cit.*, pp. 42–50.

[3] *Cleveland Trust Bulletin*, February 15, 1944, p. 4.

[4] Brief submitted to Panel of National War Labor Board, Case No. 111-6230-D, 14-1, et al, p. 136.

[5] Simon Kuznets, *National Product, War and Prewar*, National Bureau of Economic Research, Occasional Paper No. 17, especially pp. 8 and 9.

methods used, the results shown, and the implications of these results for policy. Questions as to results relate mostly to the war period, but questions as to method date back in considerable part to the 1940 and 1941 revisions, and it appears essential to consider at the outset what the index is designed to measure and how the measurement is made.[6]

WHAT THE INDEX MEASURES

The index measures the physical volume of industrial production. "Industrial" is readily identified as referring here to factories and mines, including government arsenals and shipyards. But what is "the physical volume of production"? This question is elementary, important, seldom asked, and difficult to answer in straightforward terms. It is the first of a series to be discussed.

(1) If we look at a factory in operation, with managers, machines, and workers all engaged directly or indirectly in the process of transforming raw materials into finished products we get one view of production. If we look at a hundred factories in a hundred different industries we get a more complete view, seeing different men and different machines transforming different materials into different finished products. But how can we compare and add production in all these establishments currently or even for a single year? Actually, the comparison for one year (the weight year 1937) is made in terms of what companies have on their books and report to the Census. The difference between value of goods manufactured and the cost of materials, fuels, and supplies consumed approximates the amount paid to managers and workers for their services; to factory owners for the use of their land, plant and equipment, patents and trademarks; to creditors for the use of borrowed funds; and to the government for police protection and the like. This difference is called "value-added" and in the weight year 1937 each industry has an importance in the index corresponding with the "value-added" for that industry. This measure of importance would be a little more refined if services bought from other industries, like telephone and telegraph, were omitted. Perhaps a more important detail qualifying the accuracy of the results during the war period is the use for mineral weights of total value of product rather than value-added. But there are larger questions.

[6] See: *Federal Reserve Bulletins*—Frank R. Garfield and Paul Simpson, "Revision in the Index of Industrial Production," September 1941; "The Rise in the Federal Reserve Index of Production," October 1940; Woodlief Thomas and Maxwell R. Conklin, "Measurement of Production," September 1940; Maxwell R. Conklin, "New Federal Reserve Index of Industrial Production," August 1940; Frank R. Garfield, "General Indexes of Business Activity," June 1940. A version of this last article with bibliography appeared in *The Statistical Activities of the American Nations, 1940*, issued by the Inter-American Statistical Institute.

The value-added figures, used to establish the relative importance of various physical volume figures in 1937, are market facts, reflecting appraisals by all buyers and sellers, private and governmental, no matter how the appraisals were arrived at or how they were affected by income distribution, monopolistic practices, or the state of the industrial arts in various industries. Other standards might be used for weighting. The number of units of products might be counted, regardless of kind or value. Pounds of product might all be treated alike and, for comparison with tons of railroad freight originated, an index constructed that way might serve a purpose. The index maker might modify the value-added standard, dropping out things he regarded as of no consequence, perhaps putting a negative value on things he regarded as detrimental to the community. He might make adjustments for monopoly prices, if he wanted to and could determine monopoly effects, industry by industry. He might devise adjustments to make prices of "government-bound" products comparable with those of other products, if he believed, as Mr. Kuznets does, that there is an important difference.[7] Or he might work out adjustments for degree of maturity of each industry in the weight year in terms of scale of operations, degree of mechanization, or type of market; this is another factor Mr. Kuznets considers in reweighting war products. In the Board's index, it may be repeated, market appraisals of the contributions of the various factors of production are used as reported for 1937. This year was selected as fairly representative and the results would be practically the same using the only later Census, that for 1939.

With the relative importance of various industries established for the weight year 1937, changes in production from that year are measured by physical volume series, like those for tons of steel ingots and pairs of shoes produced, or their equivalent in terms of number of man-hours or machine-hours, adjusted to represent production. The index thus reflects changes from 1937 in the physical volume of production—less accurately in wartime when products and processes change rapidly—but does not reflect changes in the prices paid for products or for factors of production. The index is computed with the 1935–39 average equal to 100, but any other period might have been used, keeping 1937 as the weight year.

From this discussion of the meaning of the physical volume of industrial production it may be inferred that for the present purpose the specific character of the final product is not quite as crucial as is suggested by Mr. Moore's emphasis on the auto-tank valuation problem.

[7] Simon Kuznets, *op. cit.*, p. 8.

The discussion also indicates that the index is not one of "effort," notwithstanding the use of man-hour figures for limited purposes; in that term the contribution of labor is not adequately described, and that of machines is omitted. "Activity" is clearly more descriptive than "effort" but appears less meaningful than "production."

(2) The index corresponds after a fashion with gross national product expressed in constant dollars but covers only factories and mines and is arrived at through the use of physical volume series, with fixed weights, rather than of current value series adjusted for price changes. Production at factories and mines in peacetime constitutes about 30 per cent of gross national product and accounts for a considerably larger share of the fluctuations in output. Production for war purposes has been concentrated to a large extent in industry and some of the rise in industrial production has been at the expense of other activities like trade, whereas ordinarily increased industrial production is a factor stimulating increased activity in these other lines. Consequently, this index should show much more rise in wartime than gross national output in real terms. The actual increase in the Board's index as compared with various gross product figures is shown in Chart I, by six month periods.

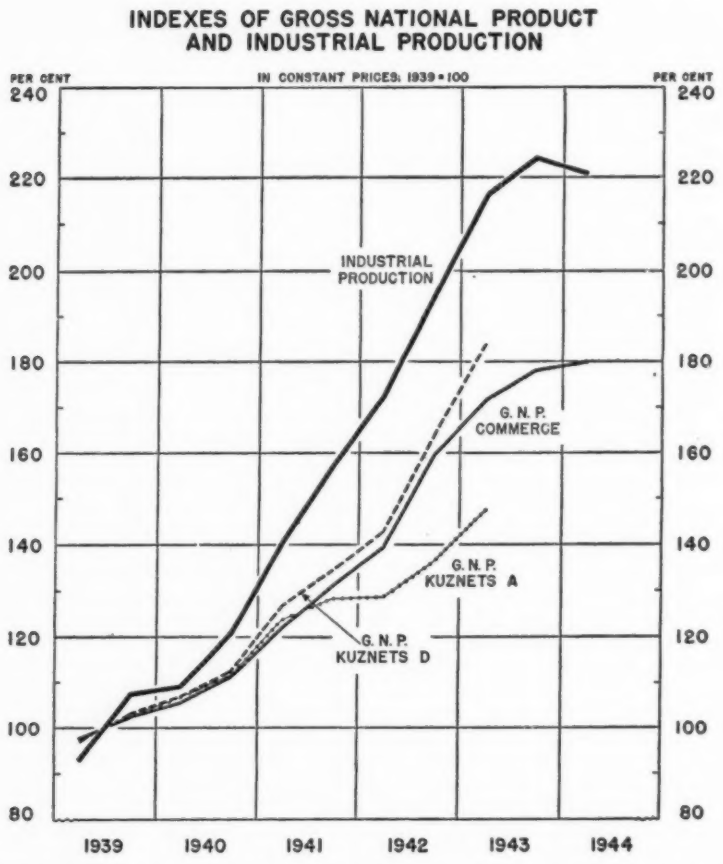
(3) The index is designed to measure production at all stages. Production of materials, not including those imported from abroad or produced in domestic agriculture, now accounts for about a third of the total, on one definition. Processing of materials, no matter where produced, accounts for two-thirds. At times it is important to distinguish the whole process from the final product; in the latter part of 1939, for example, this index rose more than an index of final product would have risen. And very often differences in timing between completion of particular finished products, such as battleships, and their production, as here defined, are substantial.

(4) The index is designed to measure production in each important industry and group of industries as well as in all industry. There are about 100 series in the index weighted to represent 18 principal Census industry groups. The series may also be grouped as consumer goods, producers' equipment and munitions, and materials. The wartime proportions of these groups are very different from the peacetime proportions, as Chart II indicates. This is to be remembered in comparing current levels with those in pre-war years or those likely or possible in post-war years. The composition of the total also needs to be considered in any study of changes in output per man-hour; value-added per man-hour is much greater in some industries than in others, nearly four times as much in chemicals, for example, as in textiles. Again, composi-

tion of the total is important to consider in any analysis of fabrication per unit of material consumed because this varies widely, being much greater in the munitions industries than in most other lines.

The attempt to measure changes in this much detail may serve to

CHART I

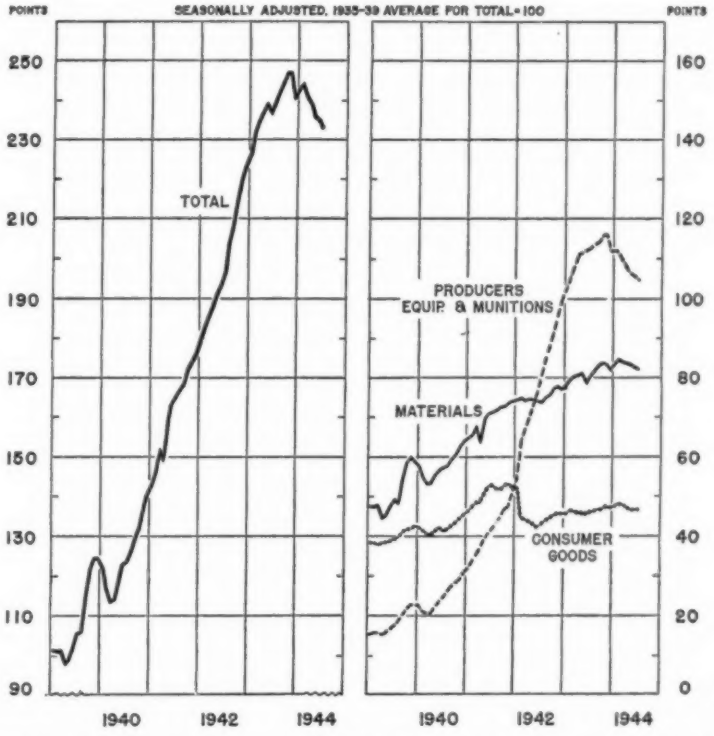


NOTE.—The Kuznets A series for gross national product is based on his preferred assumption that efficiency in use of resources in munitions and war construction in the first half of 1943 was 20 per cent lower than in five war industries in 1939; and his calculation that, considering changes in efficiency from 1939 to the first half of 1943, efficiency in munitions and war construction in 1939 was 52 per cent lower than in five war industries in that year. The Kuznets D series "disregarding relative efficiency in war production," is based on the assumption (with which he disagrees) that efficiency in munitions and war construction in 1939 was the same as in the five war industries and upon the calculation that in the first half of 1943 it was 67 per cent greater than in five war industries in 1939. The Commerce figures for gross national product are estimated from annual figures and projected to the first half of 1944 by the author.

improve the total index, unless perchance it diverts too much attention from broad issues to problems of detail. This approach also permits fairly detailed examination of the area of controversy and, perhaps, some narrowing of differences in view.

CHART II

INDUSTRIAL PRODUCTION



NOTE.—"Producers equipment and munitions" includes the iron and steel group, exclusive of pig iron and the steel subgroup; machinery; manufacturing arsenals and depots; transportation equipment; and explosives and ammunition; prior to February 1942, however, the automobile industry was included in the consumer goods group. "Consumer goods" includes furniture; the textile group, exclusive of fabrics; shoes; manufactured foods; alcoholic beverages; tobacco products; fine and tissue paper; printing and publishing; soap; drugs and cosmetics; rubber products; anthracite; and, for the period from 1939 up to February 1942, automobiles. All other series are in the "materials" group. The weights are those of the industrial production index.

HOW THE MEASUREMENT IS MADE

The index actually compiled relates of necessity to the changing industrial scene and is based on available data, both current and benchmark. Frequently because data are scarce it is necessary to use series

which are not Grade A; then when better information becomes available a revision is in order. In the extreme case of chemicals, the introduction last autumn of newly developed current data (and of 1939 Census data which had become available after the 1940 revision) raised the chemicals index sharply and contributed 11 points to the 36 point upward revision of the total index for July 1943. Lack of comprehensive benchmark data since 1939 has definitely limited analysis both of series and weighting problems.

In using current data several tasks are undertaken. One is to check the accuracy of the data for what they are; another is to see how well they represent the industry in question as to level and monthly fluctuations; a third is to make necessary adjustments, particularly to levels established biennially, annually, or quarterly by more comprehensive measures; and a fourth is to make allowances in the series accepted for non-working days and usual seasonal variations. In the war period seasonal adjustments in many lines are not required and changes in daily average adjustments can be handled without too much trouble. The really important tasks are to test the measures used and to make such adjustments as seem to be indicated. In peacetime the comprehensive study of manufacturing production made by Mr. Fabricant on the basis of Census data provides many useful checks.[8] In wartime no general Census has been taken. The 1942 Census for lumber, however, was the best ever taken and in some lines, such as chemicals, foods, and nonferrous metals, improved current information has been available. In most other lines there has been a variety of information, often compiled for administrative purposes, about units produced, materials consumed, man-hours worked, machinery installed and utilized, dollar value of shipments, price changes, and the like.

Of necessity certain special decisions about weights have been made where new products have been introduced. The automobile industry, for example, is now manufacturing mostly aircraft engines and parts, and other products not in the value-added figures for that industry in 1937. It has been figured that on the average a man-hour in this industry represented as much production, in the sense of value-added at 1937 prices, right after the transition, as it did before. In 1937, value-added per man-hour (wage-earners only) in the production of automobiles was about $1.75 as compared with $1.80 in the production of aircraft engines and $1.35 in the production of aircraft, excluding engines. In most

[8] Solomon Fabricant, *The Output of Manufacturing Industries, 1899–1937*, National Bureau of Economic Research, 1940, and unpublished study for 1939. For an analysis of mining see Harold Barger and Sam H. Schurr, *The Mining Industries 1899–1939: A Study of Output, Employment, and Productivity*, National Bureau of Economic Research, 1944. Geoffrey H. Moore, *op. cit.*, p. 35, has combined these series for manufacturing and mining.

other industries whose products have changed considerably the same procedure has been used; in a few lines, especially chemicals and petroleum products, rough direct estimates of weights appropriate for new products have been made. This is then the procedure used for handling a situation which has been difficult, but fortunately not quite so difficult as if the transition had been even more radical; if, say, the textile industry had shifted to production of aircraft. The automobile industry was asked to make particular new products primarily because the processes involved were similar in important respects to those with which the automobile industry was familiar.

The discussion of what the index measures and how the measurement is made has suggested some of the answers to various questions about measurement of wartime production. Consideration of the whole set of issues may be continued by examining the nature of important series and exploring various weighting problems.

SERIES ACCEPTED AND UNDER DISCUSSION

Only minor questions have been raised concerning the accuracy of series currently used to represent production in a wide variety of industries accounting for 65 points in the index in 1935–39 and 95 points in the year 1943. Such revisions as might properly be made in these lines would be fairly small; in the aggregate they might raise the 1943 total somewhat.

That leaves for consideration series accounting for 35 points in the base period and 144 points in 1943. This group consists of the principal series in which man-hour data are used, plus iron and steel. It consists also almost entirely of war products. The importance of various series under discussion is shown in the table.

INDUSTRIAL PRODUCTION

(Points in total index)

	1935–39 average	1939	December 1941*	1943
Total index	100.0	108.6	176.0	238.9
Accepted	64.6	70.2	93.1	95.2
Under discussion (below)	35.4	38.4	82.9	143.7
Iron and steel	11.0	12.5	21.0	22.8
Machinery	10.8	11.2	28.4	47.8
Transportation equipment	5.9	6.1	18.3	45.8
Automobiles	4.8	4.5	6.6	10.6
Aircraft and shipbuilding	.8	1.3	10.6	33.8
Railroad cars and locomotives	.3	.3	1.1	1.3
Chemicals	6.3	7.0	12.9	24.1
Rubber products	1.4	1.6	2.3	3.2

* Adjusted for seasonal variation.

In the iron and steel group the use of separate measures for open hearth and electric steel has largely met one of the most serious problems of change in product. There is real question, however, how appropriate the use of pig iron and the open hearth steel series is to represent fabricating activities in the iron and steel products industries, excluding specialized ordnance plants covered elsewhere. If man-hours worked in the regular fabricating plants were to be used instead, without any allowance for change in output per man-hour, a larger rise would be shown for the total iron and steel group. This is an instance in which physical volume figures excellent for some purposes may not be adequate for other purposes and where increased fabrication per unit of material may not have been reflected in the index. If the iron and steel group were to be listed without change in the "accepted" group, the total for that group would be 76 points in the base period and 118 points in 1943.

In the machinery industry the figures show production in 1943 over four times that in the base period, with about half the rise occurring by December 1941. A considerable part of this increase was in plants producing aircraft engines; excluding these, the level would be about three and one-half times that in the base period, with over half of the rise coming by December 1941. A considerable part of the remaining rise was in other war products, such as artillery and artillery shells, ship engines, and radar. There is, moreover, ample evidence that production of industrial equipment has been very greatly expanded to meet war requirements. By comparison the effect of reductions in output in this industry of some civilian items like electric refrigerators and sewing machines has been very small. That there has been, net, a very large increase in production in the machinery industry can hardly be questioned.

The increase actually shown for the whole machinery group reflects a rise in man-hours reported, and allowances amounting by 1943 to 5 per cent for underreporting of employment and 15 per cent for increased output per man-hour. This 15 per cent is not a measure of increase in labor productivity and should not be taken as representing the increased contribution of labor. It is simply an overall estimate of what has happened to production per man-hour as a result of many developments, including introduction of new machinery and techniques made possible by a sustained large-scale demand. Some factors such as the long working hours and the employment of inexperienced workers tend to lower output per man-hour, offsetting part of the gains from other sources. This allowance was determined through study of various

sorts of information regarding production, shipments, and the like during the war period as well as through study of broad changes in output per man-hour before the war. It is only an approximation.

It is, however, probably a much closer approximation than could be obtained by using simply volume of materials or tonnage of products, if such figures were available. Many of the new products made in this industry are exceedingly intricate and must be made to the highest specifications to meet the exacting requirements of war production and combat use. Lightness and compactness have been stressed to facilitate transport and use of munitions. All in all there has been a large increase in fabrication per unit of material in industries such as this. Further study of War Production Board records is being made to improve understanding of what has been going on in the machinery industry and also in other metal fabricating industries.

In the transportation equipment group, production has risen to about seven and one-half times the pre-war level, according to the index. Production in the automobile industry has more than doubled; in the railroad equipment industries has quadrupled; and in the aircraft and shipbuilding industries combined has risen to a level more than 40 times what it was. The difficulties of wartime measurement are illustrated in the automobile industry where consumption of steel is very much less than before the war while dollar volume of shipments is very much greater. Part of the difference reflects use of different materials, part an increase in fabrication, part a rise in prices. The increase in output per man-hour allowed for is 8 per cent from the base period, 5 per cent from 1939. This is the industry which some people have chiefly in mind when they say the total index was too high in the spring of 1942. At that time employment was considerably reduced and the Board's index for this industry, at 130 per cent of the 1935–39 average, was about a fourth below the peak of the preceding summer. Perhaps a third of this remaining production was of trucks and of special war products whose output was already well established. Any special temporary adjustment for inefficient operation would thus have applied to man-hours representing about 4 points and would have lowered the total index only slightly. If allowances of this sort had been made generally, the index would have risen somewhat less rapidly in the early part of 1942, more rapidly later.

Production in the aircraft and shipbuilding industries accounted for less than 1 point in the total index in the base period and for 34 points in 1943. Current changes shown are based on man-hour series with upward adjustments for underreporting and allowances of about 22 per

cent for increases in output per man-hour from the base period. Other available series relate to final products, and also, in shipbuilding, to work in place. From 1941 to 1943, according to the War Production Board, deliveries of military aircraft rose 3⅓ times in number and 7⅔ times in pounds of airframe weight. The more rapid rise shown by weight reflected an increasing proportion of bombers. In this same period the Board's index for production in the aircraft industry rose about 3½ times. This figure, however, is not directly comparable with the preceding figures. In 1941 the Board's series included a considerable number of civilian craft. Allowing for this, the Board's implied measure of military craft would be up over 4 times. Making a further adjustment to put the Board's figure on a delivery basis and include production of parts outside the aircraft industry, as defined in the Board's index, the rise might be about 6½ times. This is much more than the rise in number of military aircraft delivered but not as much as the rise in airframe weight. It is about the same as the rise shown by the War Production Board index of all military aircraft production, in August 1943 prices, but somewhat lower than that index would be if airplane engine production were excluded, as it is from the various figures cited above. Altogether, it appears that the Board's index of production in the aircraft industry rose less from 1941 to 1943 than production in that industry. The 1941 figure seems reasonable as compared with the base period.

In shipbuilding the rise shown by the Board's figures from 1941 to 1943 was less than that shown by the War Production Board index for estimated work in place, in August 1943 prices. Ship deliveries rose more percentagewise than work in place but were not closely related to production figures in the period of rapid change under review because of the long and changing time involved in ship construction.

The rise shown by the chemical group to a level in 1943 nearly four times that of the base period accounted for 18 points of the rise of 139 points in the total index. The group figures are based on separate series for industrial chemicals, which rose at about the same rate as the whole group; explosives and ammunition (small arms); several components such as paints, soap, rayon, and drugs; and "other chemicals." The series used prior to the revision in October 1943 was for the chemicals group as a whole, and before the 1940 revision chemicals were assumed to move with the total index (as miscellaneous industries accounting for 3 per cent of manufactures are now). The series for industrial chemicals is based on over 50 annual and quarterly physical volume series moved from month to month and kept up to date by man-hour series, adjusted. The man-hour series for explosives and small arms ammunition are adjusted partly to physical volume data, partly to estimates

derived from study of other figures. New figures and further analysis indicate that the series for "other chemical products" shows more rise than it should. In the chemical field new products are an important factor difficult to appraise.

The rubber products series, a straight man-hour series since March 1941, is not regarded as very satisfactory, owing partly to classification problems, but is more satisfactory than rubber consumption for the period when output of products using little or no rubber was an important part of the total.

Reviewing the list, it appears that the elements of change are great but that in each industry there are important features of continuity in the management, the working force, and the whole production process and that approximate answers can be obtained by study of all available information.

MATERIALS AND FINISHED PRODUCTS

This approach seems definitely preferable to estimating the total by assigning finished product weights to raw material production series, either industry by industry or on an overall basis. Materials production appears not to represent production in many of these important finished product lines where war output has increased most. This is largely because increases in fabrication per unit of material have been considerable in these lines, accounting for much of the rise in fabrication per unit of material implied for the index as a whole.[9] The drift toward more fabrication was already evident before the war and, therefore, the fact that from 1939 to 1943 the materials production index constructed by Mr. Moore showed a rise of only 37 per cent as contrasted with 120 per cent in the Board's index does not necessarily indicate too much rise in the Board's index. Further, if revisions were made in this materials index to take account of synthetic materials and the like, it would rise 45 per cent or more. Then if it were reweighted to make materials represent their respective finished products, the rise would be greater, perhaps 60 per cent or more, without allowance for changes in consumption of materials, as contrasted with production, or for changes in the amount of fabrication per unit of material.

[9] The increase of 5½ times as much in finished product as in materials by 1943, attributed to the Board's index in the *Cleveland Trust Bulletin* for February 15, 1944, reflects partly doubtful classification of items (no chemicals were included in the materials group); and comparison with 1940 levels (without reference to accumulation of materials inventories that year). Making the comparison with a different classification and with 1935–39 the rise is about 3 times as much for finished products as for materials. Then considering the matter in terms of degree of fabrication per unit of material, the rise shown from 1935–39 period is ½. This figure is not regarded, however, as a satisfactory measure because no adjustments have been made for imports and exports of materials, for unfinished materials used outside industry or for weighting difficulties which limit the meaning of any such comparison.

PLANT CAPACITY AND UTILIZATION

Considering the plausibility of the Board's index from another overall approach, note may be taken of the increase in use of plant and equipment as well as of the increase in man-hours worked. Most of the rise in output through 1941 reflected increased utilization of existing plant, as relatively little new plant had come into operation by that time. Little question has been raised concerning the index level of 175 for the end of that year, about 60 per cent above the 1939 level. During 1942 and 1943 utilization of existing plant (net of some reductions) increased considerably further and toward 20 billion dollars of new plant and equipment of most modern design was added. Difficulties in the way of determining how much this meant in terms of capacity are great but it appears that the expansion was probably 35 per cent or more. A rough calculation suggests that additions to capacity and increases in plant utilization by the end of 1943 were large enough, with man-hours meanwhile rising about 35 per cent, to permit the 40 per cent further rise shown in the Board's index from the level of 175 at the end of 1941 to the peak of 247 in the autumn of 1943.

In passing, it may be noted that overall comparisons are likely to be rough and that full use of such data as those on plant capacity, munitions output, shipments, and electric power consumption in industry can be made only on a detailed industry by industry basis. Attempts, for example, to use the War Production Board's index of finished munitions output to check the aggregate of munitions production scattered through the Board's series have yielded only broad indications as to the accuracy of the Board's representation of munitions output. This is especially true for 1942, the year most under discussion. In general such comparisons, with approximate allowances for this and that, suggest that the Board's index has not fully reflected the rise in munitions production; further work is to be done, however, in refining these comparisons.

ADVANCING INDUSTRIAL TECHNIQUES AND OBSOLESCENT WEIGHTS

In 1939 an automobile could be produced much more easily than in 1899 and many more were actually produced, to sell at prices (net of materials cost) much lower relative to prices of most other products than in 1899. The production of a single car was therefore much less important as an element of value-added in 1939 and a weighting system which used 1899 weights would have given too much importance to the rise in automobile production in the interval. With 1939 weights the rise would have had too little importance. The usual procedure would

be to compromise by using different weights for different periods or perhaps base year and given year weights for the same period. The war period of a few years may be likened, for the aircraft industry, to a decade or so and weights established six years earlier may seem out of line for 1943. Techniques in numerous other industries have also improved. Is a new set of weights in order?

The answer depends largely on what has happened to capital costs, wages, and value-added per unit (of comparable quality); what information about these matters is available; how important the whole issue may be; and how appropriate various weights might be for the period ahead as well as for the war period to date.

Mr. Kuznets, facing similar problems for gross national product, sets up a new standard for the munitions and war construction component. He reduces the importance of such production in 1939 by one-half because it was government-bound and carried on in immature industries, without presenting evidence on the relative prices of government-bound products and without saying much about standards used for judging degree of maturity. In effect he brings estimated economies of the large-scale operations of wartime back into 1939 for purposes of weighting, without including in the weights any of the special taxes or differentially increased wage rates which often go with profitable large-scale operations as actually developed. Or, looking at it another way, he brings back to 1939 certain developments which might have occurred in peacetime over an indefinitely long period, but presumably along with numerous other changes not mentioned. This reweighting is done only for the entire munitions and war construction group, not for any particular industry. Weights are not crossed, nor are adjustments made for relative inefficiency in certain other parts of the economy whose output has increased relatively little. The standards used, so far as they are set forth, do not appear adequate for meeting wartime weighting problems, at least as presented in the index of industrial production.

A basic fact to consider is that data available for 1943 are not adequate to permit a detailed study of the effects on value-added of changes in products, improvements in technique, increased utilization of plant, differential wage changes, and the like. Of less importance, the value-added figures, if available, would need very special interpretation because of price renegotiation allowances, classification problems, and the like. In any event, new weights could be regarded as typical only of a short period and would need to be crossed with pre-war weights. Some of the changes in weights would be offsetting in their effects on the level of the total index. All in all the effect of changing weights on a broad

estimating basis might be to lower the index for the war years but not enough to affect greatly the comparison between pre-war and war levels of production; meanwhile, as indicated earlier, revisions in series would probably tend to raise the index. The discussion of weights for the war period may well continue for a long time, even after some additional wartime data become available. A general revision of weights will be essential when returns from the first comprehensive post-war Census are available.

CONCLUSION

Changes in the industrial economy since 1939 have been rapid and widespread, greatly complicating the problem of measuring industrial production. An attempt has been made in the Board's index to take account of new developments as far as available information would permit. In the nature of the case the measurements for the total and for some of the parts are less accurate than those of peacetime but it is believed they are good approximations and that the index is a useful tool for analysis of war and post-war developments. A basic conclusion to be derived from the wartime record is that the productive capacity of industry is much greater than anyone had supposed. Conditions during the war period, however, have been very different from those of peacetime with respect to the type of product, the degree of fabrication, the market, the composition of the labor force, average hours worked, and the concentration of economic activity in industry. These differences need to be kept in mind in considering post-war production potentials; so also, if reference is made to developments a quarter of a century ago, should differences between the course of industrial production in this war and in the last war. No adequate measure of total industrial output is available for the first world war but it appears that the increase this time has been very much greater and that a much larger part of the increase has been in the production of highly fabricated precision equipment for use in combat and production. The Board's index can be most useful, perhaps, in studying post-war conditions, if people who refer to it take note of what happens in particular industries as well as in the total and make allowances in their comparisons from one period to another for important changes in surrounding conditions.

ECONOMIC CONSUMPTION SCALES AND THEIR USES*

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International Labour Office, Montreal

Twenty years have elapsed since Sydenstricker and King published their study on the Measurement of the Relative Economic Status of Families[1] and ten years since their consumption scale, "a device for measuring the size of families," was subjected to critical appraisal in *Methods in Social Science: A Case Book*.[2] During this period important developments have taken place in this field. A review of the status of consumption unit analysis in the light of these new researches is of interest from several points of view.

Sydenstricker and King were interested in the consumption scale as a tool in the problem of more precise measurement of the relative economic status of families. In studying the health of families in a social survey, the need was felt for some method of classifying families according to economic status in order to ascertain, if possible with numerical results, the influence of economic position upon health and morbidity. The existing consumption scales, based for the most part upon relative requirements of adults and children in terms of calories, seemed to Sydenstricker and King in need of refinement for purposes of their analysis, and they developed a technique by which a new set of values was obtained to express the relative consumption of adults and children of different age and sex on the basis of evidence of actual expenditures on food and on all items by families of varying composition. With this improved scale they were in a position to calculate the expenditures of each family per consumption unit and then to classify the families in expenditure-per-consumption-unit groups. In this process, the consumption scale is a measuring rod of relative consumption, in expenditure terms, of food and of all items, by persons of different age and sex expressed as a percentage of the consumption of the adult male.[3]

In his critique, Professor Ogburn devoted special attention to the

* This paper represents part of an International Labour Office study of consumption unit analysis which is at present in preparation. Cf. also, *Methods of Family Living Studies*, International Labour Office Studies and Reports Series N, No. 23 (Geneva, 1940), pp. 75–77.

[1] Edgar Sydenstricker and Willford I. King, "The Measurement of the Relative Economic Status of Families," *Quarterly Publications of the American Statistical Association*, Vol. XVII, No. 125, September 1921, 842–57.

[2] William F. Ogburn, "A Device for Measuring the Size of Families, Invented by Edgar Sydenstricker and W. I. King," in *Methods in Social Science: A Case Book*. Edited by Stuart A. Rice, University of Chicago Press, Chicago, Ill.

[3] In the Sydenstricker and King Scale, the unit is the consumption of the adult male 25 years old, at which age consumption was found to be at the maximum.

techniques by which the original scale (the Atwater scale based upon calories[4]) was adjusted to the expenditures of the local population group. He pointed out that theoretically each locality with its special consumption habits and local prices would have its own consumption scale: and hence, if a scale based upon a particular local group was actually to be applied generally, evidence was necessary to show that the variations, due to local differences, in scales developed for different communities were not large enough to invalidate their wider applicability. Ogburn characterized the procedure as a method of measuring "family size": the size varying according to the purpose—e.g., relative food costs, relative total expenses—and according to circumstances, such as differences in income classes, times and places.[5]

In discussing the developments which have taken place since Sydenstricker and King's article, the simplest procedure is to present the various scales which have been proposed and then to discuss them with relation to present day problems and points of view concerning economic consumption scales. At the outset, however, attention may be directed to three developments in regard to nutrition scales[6] which may help to orient the discussion. In the field of nutrition scales important developments include (1) adoption of scales for specific food elements, (2) reliance upon requirements rather than consumption and (3) a movement towards comparability and standardization. In regard to the first point separate scales are available for calories, protein, calcium, iron and other minerals, and the several vitamins. Since the purpose of the scales is, in effect, to calculate the requirements of a population group for the different food elements from the data of sex and age distribution, to compare needs with available supply or consumption with requirements, the use of requirements as a basis for determining scale values is obviously indicated. The work of the Health Organization of the League of Nations in setting up standard calorie scales and of the Food and Nutrition Board of the U. S. National Research Council in setting up standard scales for the various food elements, illustrates the trend towards standardization; and comparability may be achieved by means of conversion to standard scales, provided that data as to the sex and age composition of the population group surveyed are given. From these data, in conjunction with the scale actually used in each study, the requirements of various food elements for the popula-

[4] *Farmers' Bulletin* 142, p. 33, published by U. S. Dept. of Agriculture.

[5] "New scales should be drawn up for different income classes and different times and places . . . " (*Ibid.*, p. 217). The point was also raised whether a new scale should be constituted for each study (*Ibid.*, p. 218).

[6] A differentiation is made between nutrition scales for food elements and the economic scales to which latter the present article is devoted.

tion group of each study can be estimated according to any desired scale, and hence on a basis that permits of valid comparisons with the results of other studies.

Sydenstricker and King rejected a nutrition or calorie basis for an economic or expenditure scale; and moved in the direction of greater specificity in adopting separate scales for food expenditures, for expenditures on all other items than food and for general expenditures. Their scale for general expenditures was derived from the other two by weighting by the average expenditure on food and all other items. Their technique utilizing the data of their particular study to derive a scale for that study may be said to give an "autogenous" scale. They tested it by applying it to additional materials obtained from the same source and drew the conclusion that the scale was applicable to the same class in the same locality, though subject perhaps to inaccuracy if applied to other classes in that locality or to the same class in other localities.[7] They applied their scale to the calculation of the number of consumption units in each family as a step in the classification of families according to income per unit. In such a classification the objective is a differentiation of the families into a small number of groups ranged according to income per unit, in which small errors in the allocation of individual families are not of vital consequence. So far as standardization is concerned, the difficulties of standardization, with this type of indirect application, include not only the adoption of a uniform or equivalent scale but also of uniform or equivalent class limits to incomes and are especially great as between different localities with different consumption habits or where different currencies complicate the identification of levels of living in terms of income per unit. So far as conversion to a common basis is concerned, such conversion from one scale to another is feasible only where the scales enter into the final results directly, to show, for example, the total number of consumption units in a population group, but not where they enter indirectly as in the case of classification of families according to income per unit.

In the next paragraphs the new scales which have been developed are set forth, followed by a discussion of new developments in the application of economic scales to new problems.

Table I presents eleven food expenditure or cost scales developed subsequent to the Sydenstricker-King scale.[8] Most of these are based on actual food expenditures. Those of Stiebeling and Ward for a liberal

[7] The scale might prove "somewhat inaccurate if applied to different classes of persons" than the cotton mill workers in the locality under consideration "or to the same class in other localities." *Op. cit.*, p. 855.

[8] Scales based on calories or energy requirements are not included.

TABLE I
FOOD EXPENDITURE AND COST SCALES*

Age	Sydenstricker and King†	Williams and Lockwood¶	Germany Statistisches Reichsamt**	UNITED STATES: Wage earner study: average prices of††			Consumer purchases study***	Dept. of Agriculture (Stiebeling and Ward)§§§				Heller Committee¶¶¶
								Liberal diet	Adequate diet		Restricted diet	
	1917	1925–27	1927–28	1934	1 June 1934–31 May 1935	1935	1936–37	1933	Moderate cost 1933	Minimum cost 1933	For emergency use 1933	1937
	M F	M F	M F	M F	M F	M F	M F	M F	M F	M F	M F	M F
Under 1 Year	0.28 0.27	0.37	0.50	0.51	0.48	0.48	0.51	0.47	0.53	0.71	0.61	0.765
1	.30 .29	.37	.50	.51	.48	.48	.54	.47	.53	.71	.61	.765
2	.35 .34	.42 .40	.50	.54	.52	.51	.55	.47	.53	.71	.61	.765
3	.38 .37	.47 .42	.50	.54	.52	.51	.59 .58	.47	.53	.71	.61	.754
4	.41 .40	.50 .44	.50	.61	.59	.58	.61 .60	.56	.61	.78	.72	.754
5	.44 .43	.52 .47	.50	.61	.59	.58	.65 .63	.56	.61	.78	.72	.754
6	.46 .45	.55 .49	.50	.61	.59	.58	.73 .67	.56	.61	.78	.72	.776
7	.48 .46	.57 .51	.50	.79 .61	.77 .59	.76 .58	.80 .73	.71 .56	.74 .61	.83 .78	.86 .72	.776
8	.51 .48	.60 .52	.50	.79 .79	.77 .77	.76 .76	.87 .79	.71 .71	.74 .74	.83 .83	.86 .86	.776
9	.53 .49	.63 .55	.50	.86 .79	.84 .77	.84 .76	.91 .84	.77 .71	.83 .74	.91 .83	.92 .86	.929
10	.56 .52	.71 .58	.75	.86 .79	.84 .77	.84 .76	.95 .88	.77 .71	.83 .74	.91 .83	.92 .86	.929
11	.59 .54	.78 .60	.75	.92 .86	.91 .84	.90 .84	.98 .90	.85 .77	.89 .83	.96 .91	.97 .92	.929
12	.64 .58	.80 .63	.75	.92 .86	.91 .84	.90 .84	1.03 .93	.85 .77	.89 .83	.96 .91	.97 .92	.929
13	.69 .62	.82 .66	.75	1.01 .86	1.00 .84	1.00 .84	1.07 .97	1.04 .77	1.09 .83	1.10 .91	1.13 .92	.929
14	.77 .66	.85 .69	.75	1.01 .92	1.00 .91	1.00 .90	1.12 1.01	1.04 .85	1.09 .89	1.10 .96	1.13 .97	1.235 1.00
15	.84 .72	.88 .72	1.00 .90	1.01 .92	1.00 .91	1.00 .90	1.12 1.01	1.04 .85	1.09 .89	1.10 .96	1.13 .97	1.235 1.00
16	.90 .76	1.03 .75		1.02 .92	1.02 .91	1.02 .90	1.14 1.01	1.13 .85	1.17 .89	1.17 .96	1.24 .97	1.235 1.00
17	.94 .80			1.02 .92	1.02 .91	1.02 .90	1.14 1.01					1.235 1.00
18	.97 .82			1.02 .92	1.02 .91	1.02 .90	1.14 1.01					1.235 1.00
19	.98 .84			1.02 .92	1.02 .91	1.02 .90	1.14 1.01					1.00 .902
20	.99 .85			1.02‡‡ .83§§	1.00‡‡ .83§§	1.00¶¶ .90§§	1.00††† .92‡‡‡					
21	1.00 .85											
22	1.00‡ .86§											
Adult: moderately active		1.00 .78						1.00 .85	1.00 .89	1.00 .96	1.00 .97	1.00 .902
very active		1.25 .85						1.17 1.04	1.13 1.09	1.12 1.10	1.28 1.13	

* Except when otherwise noted, the last figures shown apply also to higher wages. † Edgar Sydenstricker and Willford I. King, "The Measurement of the Relative Economic Status of Families," *Quarterly Publication of the American Statistical Association*, Vol. XVII, No. 135, Sept. 1921, p. 849. ‡ For years over 22: 23–44, 1.00; 45–48, .99; 49–51, .98; 52–54, .97; 55–57, .96; 58–60, .95; 61–64, .94; 65–69, .93; 70–74, .92; 75–79, .91; 80, .90. § For years over 22: 23–43, .86; 44–47, .85; 48–50, .84; 51–53, .83; 54–57, .82; 58–60, .81; 61–63, .80; 64–68, .79; 69–74, .78; 75–80, .77. ¶ F. M. Williams, and J. E. Lockwood, An Economic Study of Food Consumed by Farm and Village Families in Central New York, N. Y. (Cornell) Agricultural Experiment Station Bull. No. 502, (1930). ** Germany. Statistisches Reichsamt. "Die Lebenshaltung von 2,000 Arbeiter-, Angestellten-, und Beamtenhaushaltungen"; *Einzelschriften zur Statistik des Deutschen Reiches*, No. 22, 2 vols. Berlin, 1932. †† Scale of customary food expenditures, Estimates of the Bureau of Home Economics—Bureau of Labor Statistics. F. M. Williams and Alice C. Hanson, *Money Disbursements of Wage Earners and Clerical Workers 1934–36*. Summary Volume. U. S. Bureau of Labor Statistics, Bull. 638, p. 363. ‡‡ Full-time employed; for unemployed and part-time employed, 0.90. §§ Moderately active; for women 20 and over, active, 0.92. ¶¶ Full-time employed; for unemployed and part-time employed, .89 *** Hazel K. Stiebeling, Day Monroe, Esther F. Phipard, Sadye F. Adelson and Faith Clark, Family Food Consumption and Dietary Levels. Five Regions, U. S. Department of Agriculture, Misc. Publ. No. 452, p. 251. ††† Moderately active; for active, 1.12. For ages 75 and over, 0.90 for moderately active, 0.95 for active. ‡‡‡ Moderately active; for active, 1.00. For ages 75 and over, 0.85 for moderately active, 0.90 for active. §§§ H. K. Stiebeling, and M. M. Ward, Diets at Four Levels of Nutritive Content and Cost. U. S. Dept. of Agriculture, Circular No. 296, p. 26. (1933). ¶¶¶ Emily Harriet Huntington, and Mary Gorringe Luck, Living on a Moderate Income: the incomes and expenditures of street-car men's and clerks' families in the San Francisco Bay Region, with an Introduction by Bruno Lasker; a report in the International Research series of the Institute of Pacific Relations. Berkeley, Cal., University of California Press 1937. Appendix A. The figures give relative costs of a minimum standard diet for persons of different age and sex, the adult male (moderately active) = 1. (The figure for sedentary adult males = .902.)

diet, adequate diet and restricted diet are calculated on the basis of the cost of diets at different dietary levels as set up by nutrition experts. The three scales of the U. S. study of the expenditures of wage earners and clerical workers (referred to subsequently as the U. S. Wage Earner Study) are of special interest as illustrating the effects on a food scale of changing prices over a period of two years.[9]

The outstanding difference between the later and the earlier scales is the increased values assigned to children. This doubtless reflects the change in food habits in accordance with the modern tendency towards an increase in provision of the relatively more expensive protective foods in the diet, especially for children.

In Table II specific scales are presented for clothing, rent, "other items," and "all items except food."

In addition to those shown, a series of detailed scales were developed by Kirkpatrick for farm families, for food, clothing, rent, furnishings, household operation, health maintenance, advancement, personal goods and insurance; in these the ratings were based not solely on age and sex but in some cases on size of family, of number of children in the household, or similar points of family composition.[10]

In Table III, four all-items expenditure scales are shown, including two which antedate the Sydenstricker-King scale, and one, based on

[9] "The scale of food expenditure units was based on data secured from the Bureau of Home Economics showing quantities of food consumed by persons of different age, sex and physical activity, estimated partly on the basis of energy requirements and partly on the basis of actual food consumption of families of wage earners and clerical workers." Faith M. Williams and Alice C. Hanson, *Money Disbursements of Wage Earners and Clerical Workers 1934–36*. Summary Volume, U. S. Bureau of Labor Statistics, Bull. No. 638, p. 50, note 9.

[10] Evelyn G. Tough and E. L. Kirkpatrick, "Scales for Measuring the Standard of Living." this JOURNAL, Vol. 28, No. 181, March 1933, pp. 55–63. See also E. L. Kirkpatrick, "The Standard of Life in a Typical Section of Diversified Farming," Cornell University Agricultural Experiment Station Bull. 423, and "The Relation of the Ability to Pay to the Standard of Living," U. S. Department of Agriculture Bull. 1382.

The food scale distinguishes between the first person in each sex and age group and additional persons: for the first person—children under 6, .3; 6–11, .4; 12–14, .6; males 15–18, .8; males 19 and over 1.0; females 15–18, .7; females 19 and over .9, For additional persons, the scale rating is the same as that shown diminished by 0.1 point.

The clothing scale is as follows: operator 1.0; home maker 1.0; other persons: 1–5 years, 0.4; 6–11, .6; 12–14, 1.0; 15–18, 1.3; 19–24, 1.7; over 24, 1.4.

The rent scale: operator 1.0; homemaker 1.0; other persons: 15 years of age and over, males: first .2, second 0, third .2, fourth 0, etc.; females: first .2, second 0, third .2, fourth 0, etc.; 6–14 years of age, males: first .1, second 0, third .1, fourth 0, etc.; females: first .1, second 0, third .1, fourth 0, etc. Under 6 years of age 0.

The furnishings scale (also used for household operation, and for life and health insurance): operator 1.0; homemaker 1.0; other persons regardless of age: first .4; second .3; third .2; fourth .1; additional 0.

Maintenance of health scale: operator 1.0; homemaker 1.0; children under 6 years, .6; 6–24 years, .2, over 24, .4.

Advancement scales, operator 1.0, homemaker 1.0; children under 6, 0; 6–14, .1; 15–18, .3; over 19, .5.

Personal goods scale: operator 1.0, homemaker .6; children: under 6, .2; male 6–14, .4; 15–18, .5, 19 and over 1.0; female, 6–14, .3; 15–18, .5; 19 and over, .6. Tough and Kirkpatrick, *op. cit.*, p. 57–58.

TABLE II

EXPENDITURE SCALES FOR ITEMS OTHER THAN FOOD*

Age	Clothing		Rent and housing		All specific items		All items except food	
	U. S. Wage Earner Study†		Bowley§		Sydenstricker and King¶		Germany††	
	M	F	M	F	M	F	M	F
Under 1 Year	0.19	0.19	0.25	0.25	0.11	0.11	0.20	
1	.19	.19	.25	.25	.13	.13	.20	
2	.34	.38	.25	.25	.16	.16	.20	
3	.34	.38	.25	.25	.17	.17	.20	
4	.34	.38	.25	.25	.19	.18	.20	
5	.34	.38	.50	.50	.20	.19	.20	
6	.48	.47	.50	.50	.22	.21	.30	
7	.48	.47	.50	.50	.24	.23	.30	
8	.48	.47	.50	.50	.26	.25	.30	
9	.53	.56	.50	.50	.28	.27	.30	
10	.53	.56	.50	.50	.31	.30	.50	
11	.53	.56	.50	.50	.33	.33	.50	
12	.63	.77	.50	.50	.35	.37	.50	
13	.63	.77	.50	.50	.40	.40	.50	
14	.63	.77	.75	.75	.46	.44	.50	
15	.88	1.01	.75	.75	.55	.48	.70	
16	.88	1.01	.75	1.00	.65	.57	.70	
17	.88	1.01	.75	1.00	.77	.60	.70	
18	1.01	1.28	1.00	1.00	.86	.61	.70	
19	1.01	1.28	1.00	1.00	.92	.63	.70	
20	1.01	1.28	1.00	1.00	.95	.63	1.00	.90
21 +	‡	‡	1.00	1.00	**	**	1.00	.90

* Unless otherwise noted, the last figures given apply also to higher ages.

† Faith M. Williams and Alice C. Hanson, *Money Disbursements of Wage Earners and Clerical Workers 1934–36*. Summary Volume. U. S. Bureau of Labor Statistics Bulletin No. 638, pp. 364.

‡ Males: for ages 15–20 the figures given above are for "at school": for ages over 15 figures are given also for groups "at home," "clerical," and "wage earners." The wage earner figures are: 15–18, 1.02; 18–21, 1.13; 21–24, 1.07; 24–27, 1.00; 27–30, .96; 30–36, .92; 36–42, .87; 42–48, .81; 48–54, .75; 54–60, .69; and 60 and over, .60. Females: for ages 15–20 the figures given above are for "at home." For ages over 15 figures are given also for groups "at home," "clerical" and "wage earner." The wage earner figures are: 15–18, 1.08; 18–21, 1.63; 21–24, 1.60; 24–27, 1.46; 27–30, 1.36; 30–36, 1.23; 36–42, 1.07; 42–48, .94; 48–54, .84; 54–60, .76; over 60, .67.

§ See Faith M. Williams and Carle C. Zimmerman, *Studies of Family Living in the United States and Other Countries: An Analysis of Material and Method*. U. S. Dept. of Agriculture, Misc. Publ. No. 223, p. 56.

¶ Edgar Sydenstricker, and W. I. King, "The Measurement of the Relative Economic Status of Families" *Quarterly Publication of the American Statistical Association*, Vol. 17, No. 135. Sept. 1921, p. 853. The expenditures thus covered exclude rent and similar undistributable items as well as food.

** Figures are given in the source for each age up to 80, for which the ratings are .43 and .25 for male and female respectively. The unit figure of 1.00 is for males at age 25.

†† Germany, Statistisches Reichsamt. "Die Lebenshaltung von 2,000 Arbeiter-, Angestellten-, und Beamtenhaushaltungen," *Einzelschriften zur Statistik des Deutschen Reiches*, No. 22, Berlin, 1932.

the writer's estimate for the U. S. Wage Earner Study, which is subsequent to it.

The paucity of all-items scales is in marked contrast to the relative abundance of new food expenditure scales; the latter reflect the increased attention being paid to diets and parallels the development of

specific scales for different nutrients. Where income or expenditure levels are needed in connection with food studies, recent practice has preferred a specific classification based on food expenditure per food expenditure unit, in place of the general classification per general expenditure unit.

An important reason for the paucity of all-items scales on the same level of technical elaboration as those for food and clothing is the tendency observed in a number of recent studies to calculate the number of consumption units in each family, not from the sex and age composition in conjunction with an all-items scale, but as a weighted harmonic average of the number of specific food-expenditure units, clothing-expenditure units and other-items-expenditure units following the procedure first suggested by Kirkpatrick[11] in 1921–22. This method was followed also, for example, in the U. S. Wage Earner Study of 1934–36.[12]

This technique suggests two important points. First, that all-items scales can be constructed by weighting specific scales for the component elements of the budget as well as by a direct technique. Secondly, this draws attention immediately to the inequality of coverage of the different elements of the budget: food and clothing are relatively well covered, but rent and miscellaneous items almost not at all. If these latter enter into the final all-items scale with a weight of approximately 50 per cent, the inadequacy of coverage is serious. To these difficulties must be added the further fact that the determination of scale values in the case of expenditures which are family rather than individual in character, such as rent, household expenditures and certain miscellaneous items may involve arbitrary judgments or exclusions.

[11] Evelyn G. Tough and E. L. Kirkpatrick, "Scales for Measuring the Standard of Living," this JOURNAL, Vol. 28, No. 181, March 1933, p. 57.

In the calculation the food expenditure per food unit, the clothing expenditure per clothing unit, and other expenditures per other-items unit are added together to give expenditure per "cost-consumption" unit, and this figure divided into the total expenditure of the family gives the number of "cost-consumption" units in the family.

In practice the cost-consumption unit method is somewhat more flexible since in determining the number of units in one or more of the subgroups, the number of persons in the family may be utilized instead of sex and age data.

[12] Faith M. Williams and Alice C. Hanson, *Money Disbursements of Wage Earners and Clerical Workers 1934–36*. Summary Volume. U. S. Bureau of Labor Statistics Bull. No. 638, pp. 362–366. In the Table, the last column represents an estimated average of the food, clothing, and "all-other" items scales (estimated by the writer): the number of units in each family for "all other" items being placed, as stated in the study, equal to the number of "equivalent full-time persons in the economic family." A weighted average varying with the expenditures of each family, but not a harmonic average, was utilized in the German study of 1927; the number of consumption units in each household was calculated as the weighted average of the number of food units and the number of "other items" units, the weights being the amounts expended in each household upon food and other items respectively. Germany. Statistisches Reichsamt. "Die Lebenshaltung von 2,000 Arbeiter-, Angestellten-, and Beamtenhaushaltungen," *Einzelschriften zur Statistik des Deutschen Reiches*, No. 22, Berlin 1932, Vol. I, pp. 11–12, and esp. p. 238.

TABLE III

GENERAL EXPENDITURE (ALL ITEMS) SCALES*

Age	Engel† (1895)		Germany‡ Stockholm (1907–08)		Sydenstricker and King§ (1917)		U. S. Wage Earner Study** (estimated)	
	M	F	M	F	M	F	M	F
Under 1 year	0.29		0.10		0.22		0.74	
1	.31		.10		.24		.74	
2	.34		.10		.28		.75	.77
3	.37		.10		.31		.75	.77
4	.40		.20		.33		.79	.79
5	.43		.20		.35		.79	.79
6	.46		.20		.38		.80	.80
7	.49		.30		.40		.86	.80
8	.51		.30		.42	.41	.86	.86
9	.54		.30		.44	.43	.89	.87
10	.57		.40		.47	.45	.89	.87
11	.60		.40		.50	.48	.91	.90
12	.63		.40		.54	.51	.93	.92
13	.66		.50		.59	.55	.96	.92
14	.69		.50		.66	.60	.96	.94
15	.71		.70	.60	.74	.65	.99	.97
16	.74		.70	.60	.81	.71	.99	.97
17	.77		.90	.70	.88	.74	.99	.97
18	.80		.90	.70	.93	.76	1.01	.97
19	.83		1.00	.80	.96	.78	1.01	.97
20	.86				.98	.78	1.00	.94
21	.89	.86			.99	.79		
22	.91	.86			.99	.79		
23	.94	.86			1.00	.79		
24	.97	.86			1.00	.79		
25 and over	1.00	.86			¶			

* Unless otherwise noted, the last figures shown apply also to higher ages.

† The "quet" scale transferred to the adult male 25 and over as unity. E. Engel, Die Lebenshaltung belgischer Arbeiterfamilien, früher und jetzt. *Bull. Internat. de Statistique*, Vol. IX, 1ére livraison, 1895, p. 5.

‡ Germany. Statistisches Reichsamt. Abteilung für Arbeiter-statistik. Wirtschaftsrechnungen minder-bemittelter Familien im Deutschen Reich. Sonderheft zum *Reichsarbeitsblatt*, 1909. Galle: Stockholmer Wirtschaftsrechnungen (1907–1908), *Jahrbuch für Nationalökonomie und Statistik*, 1911, Vol. 96 (Third Series Vol. 41), p. 368.

§ Edgar Sydenstricker and Willford I. King. "The Measurement of the Relative Economic Status of Families," *Quarterly Publication of the American Statistical Association*, Vol. XVII, No. 135, Sept. 1921, p. 854.

¶ For ages over 25, the scales are: Males: 25–26: 1.00; 27: .99; 28–29: .98; 30–31: .97; 32–33: .96; 34–35: .95; 36–38: .94; 39–42: .93; 43–45: .92; 46–47: .91; 48–49: .90; 50–51: .89; 52: .88; 53: .87; 54: .86; 55: .85; 56: .84; 57–58: .83; 59: .82; 60–61: .81; 62–63: .80; 64–65: .79; 66–68: .78; 69–70: .77; 71–73: .76; 74–78: .75; 80: .74; Females: 25: .79; 26–30: .78; 31–33: .77; 34–36: .76; 37–38: .75; 39–41: .74; 42–43: .73; 44–45: .72; 46–47: .71; 48–49: .70; 50–52: .69; 53–54: .68; 55–57: .67; 58–60: .66; 61–64: .65; 65–67: .64; 68–73: .63; 74–80: .62.

** Estimated by the author as a weighted average of scales for food, for clothing and for "all other items," the latter being given a scale rating of 1.00 at all ages: the weights used were 3, 1, and 5 respectively for food, clothing and all other items. No all-items scale is given in the report; the method used in the study was to calculate the number of expenditure units in each family by dividing the total amount of expenditure by the sum of (1) the food expenditure per food expenditure unit, (2) clothing expenditure per clothing expenditure unit, and (3) other expenditures divided by the number of equivalent full-time persons in the economic family. See Faith M. Williams and Alice C. Hanson, *Money Disbursements of Wage Earners and Clerical Workers, 1934–36*. Summary Volume. U. S. Bureau of Labor Statistics Bulletin No. 638, pp. 363–366.

A second reason for the relative lack of all-items scales lies in the technical difficulties of preparing a new all-items scale in time for use in analyzing the data of the study on which it is based. The delays involved in a complete preliminary analysis of the data, to construct a scale adapted to the material of the study before any other analysis is undertaken, are often regarded as prohibitive in view of the pressure under which large scale investigations are conducted.

Finally, the adoption of the classification according to family type has led to a somewhat lessened emphasis upon all-items scales.[13] The latter have served various purposes, one of which has been to express in numerical relation the demand for consumption goods represented by different family members or additions to the family. But the demand for consumption goods represented by infants or very young children, for example, in families of man, wife and one child can be studied more closely and the results presented more convincingly by an analysis in which families of this type are segregated for examination than by a technique which merely adds their consumption unit value to that of other family members in all types of families. It follows, however, that in the analysis by family type each type group is studied separately, and no attempt is made to summarize or cumulate the results.

When the mass of material permits, detailed study of habits of consumption and expenditure can be made for each important family type; the types chosen are, for example, families with two adults only, families with man, wife and one child, families with man, wife and two to four children, families with man, wife and five or more children, etc. Obviously the significance of the analysis depends in part upon the specific character of the family types: if, for example, light is desired upon the character of the expenditures resulting from the addition of a baby or infant to a family of two, the families studied should be limited to those cases of families of man, wife and one child in which the child is under the age of one or two years. Obviously, also with the greater degree of specificity in the families selected for study, a larger total mass of materials is required to yield a sufficient volume for the detailed groups.

When a cumulative result is required, therefore, as in combining all the data of a study according to economic status groups, the use of a consumption scale is still needed. Also where additional attention needs to be paid to age differences or to the number of individuals of a particular age class, for example, young children, in the analysis of family

[13] In the U. S. Consumer Purchases Study, the analysis according to all-items expenditure units was dropped.

type groups, the consumption unit technique is helpful in addition to the classification according to family type.[14]

Two other points deserve attention. None of the scales as thus developed attempts to differentiate in scale values between different income levels. As to such differences Sydenstricker and King stated that for the families in their survey "differences in income did not seem radically to affect the character of the scales," but admitted that their materials included "too few families of high income to afford an adequate basis for definite conclusions."[15] The procedure mentioned above —of calculating the number of consumption units in each family by weighting by the relative expenditures in that family on food, clothing, and other items—takes this difference in income levels into account in part, so far as differences in proportionate expenditure on food and miscellaneous do accompany differences in income levels: on the other hand no separate scales for the different income levels are applied.

The second point concerns the proliferation of specific economic scales in terms of conceptual schemata of consumption as well as of actual habits. In addition to scales derived from the data of actual consumption of specific population groups studied by the usual statistical techniques, scales may be developed on the basis of estimated "requirements" as to food, clothing, medical services or social-economic "standards" of living. Sydenstricker and King dealt with the former method. Either type of scale can be used to differentiate a population into groups according to income per unit. The latter can be utilized to compare the actual expenditures of families for food, for example, with the expenditures required for a given level of food consumption, thus making possible a conclusion in regard to the sufficiency of food expenditures to maintain an adequate diet. Such a comparison is in any case, a poor substitute for sound nutrition analysis on the basis of foods actually consumed. The distinction between the two methods is perhaps less than appears at first sight: both are for definite "specifications," in one case defined in terms of customary habits of a particular group and determined by statistical techniques, in the other defined in terms of "desirable" or standard "requirements" and determined by experts or on the basis of a consensus of opinion. In any case, the difference in the cost per unit (the adult male)—of customary consumption or of "requirements"—is of course large and important; but the differences in scales representing the relative costs for persons of different age and sex

[14] Allen reaches the conclusion that the family type analysis is more important than the consumption unit analysis. See R. G. D. Allen, "Expenditure Patterns of Families of Different Types," in *Studies in Mathematical Economics and Econometrics*, in Memory of Henry Schultz. (Ed. by Oscar Lange, Francis McIntyre, and Theodore O. Yntema) pp. 190–207, esp. 200–202.

[15] *Op. cit.*, p. 855.

to that of the adult male, are relatively minor, though doubtless ample to justify the adoption of the best scale in place of one poorly adapted to the needs of the particular problem.

As to the future, three lines of development of economic scales may be emphasized: possibilities of analysis of levels of living by means of specific scales, increased attention to direct uses of economic scales, and application of scales to international comparisons.

The development of specific scales for food expenditure, clothing expenditure, etc., in conjunction with all-items scales, in terms of specifications for different levels of living, makes possible a breakdown of the concept of the general level of living into its component parts. Thus, for example, if different levels of food consumption are designated by the letters A, B, C, D, etc., each defined in terms of food expenditure per food unit, and clothing levels are similarly defined in terms of clothing expenditure per clothing unit, etc., it becomes possible to describe the habits of families at different levels of general expenditure in terms of the levels of the several components. The level of living of a family then becomes a group of levels, for food consumption, for clothing, for rent, etc. With the aid of these specific levels of expenditure on specific items, in comparison with the concrete elements of food consumption, for example, different degrees of efficiency of consumption, waste, etc., may be distinguished.[16]

Secondly, the use of economic scales in direct applications is increasing. For example, the scale values of food costs for each year of age in conjunction with the food cost of the adult male[17] were utilized in a recent estimate of the cost of feeding a child from birth to 18 years of age. Obviously, such an estimate depends for its accuracy upon the accuracy of the individual scale values for each sex and age in the food expenditure scale. Similarly, estimates of the total cost of food, clothing, or other items of expense, or of all items in the cost of living for families, groups or the total population of a community may be made by means of scale values in conjunction with the costs for the adult male unit; and as a corollary, the amounts required to raise families, groups or the total population up to a particular level of living, e.g., the relief level, may be estimated.[18]

[16] As an example of this type of analysis, the correlation of the grade of diet with food expenditure per food unit may be cited. See Hazel K. Stiebeling, "The Dietary Situation in the United States." In *Proceedings*, National Nutrition Conference for Defense, May 26, 27, 28, 1941. Washington, D.C., pp. 82–87.

[17] See "The Cost of Feeding a Growing Child," *Statistical Bulletin* (Metropolitan Life Insurance Company). Vol. 24, No. 9, September 1943, pp. 7–9.

[18] This technique as applied to relief may be viewed as an extension of that used in the relief of dependent families in the Chicago Standard Budget, a procedure which embodied implicitly a set of scale values. See F. Nesbitt, *The Chicago Standard Budget for Dependent Families.*

An important application of economic scales is to estimate requirements in monetary terms for the relief of populations, for example, of the occupied countries of Europe. The cost of feeding and clothing the population in liberated areas may be estimated on the basis of the sex and age distribution of the population, in conjunction with the costs of feeding and clothing persons of different sex and age. Or the cost of maintaining a population at the relief level may be estimated by applying to sex and age composition the cost of relief for persons of different sex and age as embodied in a consumption scale at the relief level. Theoretically, this requires a scale which is based upon local consumption data[19] and which takes into account the specific level of the relief operation.

This raises questions of the applicability of scales to different places, and thus leads to the consideration of the problem of international standardization and international comparisons.

The problem of international comparisons may be envisaged in terms of determining the cost of maintaining different population groups at the same level of living in different places. This involves three elements: the problem of determining the equivalence of the commodity and service elements of the standard in different places, the cost of maintaining the adult male at the given level in each place, and the relative costs of persons of different sex and age in terms of the adult male, that is, the scale valid for each place.

If the level of living is defined in broad terms as the "poverty line," the "health and decency" level, the "comfort" level, etc., the basic problem for international comparisons is to draw up the lists of goods and services, in specific amounts, which represent, for the adult male, the desired level in each of the communities for which estimates are sought. In concrete terms, having defined the "poverty line" in York, England, in terms of a standard set of commodities, what changes would be required to make it applicable, for example, to Chicago, Illinois, or Geneva, Switzerland? In each place the cost of the set of commodities which define the particular standard for the adult male can be ascertained according to local prices. Similarly, the relative scale values for persons of different sex and age in terms of the adult male can be determined under the conditions set by the local components of the standard and local prices. With these elements, it becomes possible to estimate (a) the number of consumption units in a local population, (b) the total cost for the particular population of maintaining the given standard,

[19] Also local price data, if relief is to be operated through local markets.

and (c) the cost of maintaining populations in different places at the same standard.

This statement indicates the solution of the problem of comparability of economic scales for purposes of international comparisons. The scales themselves may not be strictly uniform (though, in practice, they may be closely similar); but the final results in terms of costs of a particular level of living should be theoretically comparable. The value of the results depends upon validity of the scales each for its local community and local prices as well as upon the validity of the methods adopted for determining the component goods and services in different places so that they represent the same level of living; since errors in the scale enter directly in the final result, the scales must, of course, be as accurate as possible.

This brief statement doubtless passes over too lightly the difficult problems involved in criteria for establishing equivalent levels of living in different places. An entire literature has grown up around this topic.[20] Special methods and new techniques may be required before a satisfactory solution is reached.

The problem of standardization may be approached also in the light of the similar movement in the case of nutrition scales. Standardization is applied to the specific scale. The specificity characteristic of nutrition scales has its counterpart in economic scales but with differences: first, the specific economic scales for food, clothing, etc., do not exclude the all-items scale where money values are used to equate the demand for different items of expenditure; and secondly, the economic scales are specific to habits of expenditure,[21] to local price structure, and to the particular level of living. The standardization of economic scales therefore must resolve the problems inherent in differences in these specific characters, either by demonstrating that the differences are of no substantial importance, or by reaching a basis of comparison on equivalent levels of living where local habits and local prices are taken into account. Secondly, the nutrition scales to be standardized are standardized on the basis of requirements. Economic scales of autogenous character applicable only to a particular study offer no possibility of

[20] Cf., for example, International Labour Office: "A Contribution to the Study of International Comparisons of Cost of Living," *Studies and Reports Series N.*, No. 17 (Geneva, 1932); also, Robert Morse Woodbury, "International Comparisons of Food Costs," International Labour Office, *Studies and Report Series N.*, No. 24, esp. pp. 34–35, 61–63.

[21] The habits of expenditure may be "customary" and characteristic of a particular level of living, or conceptual as constituting a set of expenditures which will meet, in the judgment of experts, the minimum "requirements" for living at a level, for example, of adequate food consumption, maintenance of health, satisfactory clothing standards, etc. Obviously the techniques for establishing these so-called "requirement" scales are different from those for establishing scales based upon customary habits.

standardization: economic scales can be standardized only on the basis of common "specifications" for a particular level of living, where the term "specifications" for a socio-economic level of living corresponds to the physiological "requirements" for a level of nutrition. Thirdly, standardization is particularly useful where the scales are applied in direct uses, such as those illustrated in the preceding paragraphs; but when they are applied indirectly, as in the case of income per consumption unit, the difficulties are greater and the advantages less; hence, the growing importance of these direct applications increases the need for such standardization.

In conclusion, the twenty years since Sydenstricker and King's paper have seen a marked development of food expenditure scales and modest additions to the group of other specific scales. In all-items scales, however, comparatively little advance has been made, owing in part to the growing reliance upon an approximate method of analysis per capita (or per consumption unit according to any of the standard scales) as sufficiently good for the indirect uses to which these scales have been mainly applied. In fact for these indirect uses there is much to be said in favor of adopting the per capita basis of calculation, since it has the advantage of being easily comprehended and in comparisons with other studies complications arising from differences in scale values are avoided. But with increased attention to direct uses of economic scales, as in estimates of international relief costs, we may expect important developments in these scales and in particular a movement toward international standardization as the problems involved in comparing standards of living in different places reach a satisfactory solution.

THE DISTRIBUTION OF PRIVATE, NON-AGRICULTURAL EMPLOYEES IN THE UNITED STATES BY STRAIGHT-TIME HOURLY WAGE RATES*

By David R. Roberts

Until a few months ago a comprehensive frequency distribution of employees by hourly wage rates could have been constructed only by sheer guess work. Recently sample data have become available from which the distribution which appears as Table II was constructed. The data are satisfactory for the areas and lines of business covered but they constitute a very limited sample. Therefore, in using them, it was necessary to make a number of assumptions, and accordingly more than usual interest attaches to a description of the techniques employed. Since the procedures varied from one field of business to another they will be elaborated along industry lines.

Before commencing a description of techniques, however, the precise coverage of the distribution will be indicated. Table I shows the magnitude of the civilian labor force, the groups excluded from the study and the balance of employees who are covered. Governmental employees were excluded because the data are inadequate and what figures are

TABLE I

BREAKDOWN OF CIVILIAN LABOR FORCE, JANUARY 1944

(in millions of employees)

Civilian labor force		51.4
Deduct:		
Unemployed	1.1	
Agricultural	6.6	
Governmental	5.6	
Own account	2.6	
Employers	1.9	
Unpaid family workers	.4	18.2
Private non-agricultural employees		33.2
Deduct:		
Non-wage earning employees† in manufacturing	2.3	
Non-wage earning employees† in mining	.2	
Non-wage earning employees† in construction	.1	
Domestic servants	1.6	
Professionals	1.3	5.5
Private non-agricultural employees included in Table II		27.7

† This category consists of clerical, technical and supervisory employees.

* This study is a revision of one made in the spring of 1944 for the National War Labor Board, Wage Stabilization Division, Research and Statistics Branch. Since that time more refined techniques have been applied to the basic data with the result that the figures presented here differ in some details from those in the original War Labor Board report.

available are in monthly or annual terms and cannot be combined with the hourly data secured for the other categories. Similar considerations apply to agricultural employees. Clerical, technical and supervisory workers were excluded in specified industries because data were unavailable. The same consideration dictated the exclusion of domestic servants. In the case of professionals limited data are available but they are in monthly or annual terms and are three years old.

The manufacturing distribution is based on a distribution as of June 1943 prepared by Messrs. R. J. Myers and H. D. Bloch of the Bureau of Labor Statistics and published in the October 1943 issue of the *Monthly Labor Review*. These investigators did not make an original survey in June 1943; they took over, as raw materials for their study, fifty-eight distributions of particular manufacturing industries which had been compiled and published by the Bureau between 1939 and 1942. The industries surveyed were taken to typify the major industry groups in which they fell. The original distributions were accordingly brought up to date, inflated to the total employment in the respective major industry groups, and then combined into a single distribution for all manufacturing. In general, the adjustment procedure employed was to split each original distribution into 1-cent class intervals. In these cases the lower limits of the intervals were multiplied by the ratio of average straight-time hourly earnings in the appropriate industry group in June 1943 to average straight-time hourly earnings in the same industry group on the date of the survey, and the frequencies were then regrouped into 10-cent intervals. In some instances other adjustments were made, e.g., to give effect to a minimum wage imposed on a particular industry since the survey date under the Fair Labor Standards Act.[1] The Myers-Bloch distribution was brought up to January 1944 by a method similar to that by which it had been brought up to June 1943, and it was then adjusted to the total number of manufacturing wage earners in January 1944.

Except for the effect given to changes in minimum wage laws, which was significant in a few lines, the foregoing procedure amounts to constructing new distributions such that their arithmetic means and ranges[2] shall be X per cent of those of the old distributions and such that their skewness shall be the same as that obtaining in the old distributions. Changes in skewness are highly important in wage distribu-

[1] For a further elaboration of the technique consult *Monthly Labor Review*, October 1943, "The Level of Factory Wage Rates in Wartime" and *Monthly Labor Review*, June 1942, "Distribution of Factory Workers by Hourly and Weekly Earnings."

[2] The new range need not be precisely X per cent of the old but it will closely approximate that figure.

TABLE II

ESTIMATED FREQUENCY DISTRIBUTION OF PRIVATE, NON-AGRICULTURAL EMPLOYEES* BY STRAIGHT-TIME WAGE RATES† AS OF JANUARY 1944

(in thousands of employees)

Hourly rate	Manufacturing	Mining	Construction	Transportation, communication & public utilities	Retail trade	Wholesale trade	Finance, insurance & real estate	Services	Grand total	Per cent	Per cent cumulative	Hourly rate
Under 20 cents‡	—	—	—	—	16	—	—	79	95	.3	.3	Under 20 cents‡
20 & under 30	—	—	—	—	260	1	—	215	476	1.7	2.0	20 & under 30
30 " " 40	122	—	—	26	1,002	21	12	388	1,571	5.6	7.6	30 " " 40
40 " " 50	965	4	8	108	1,336	155	136	371	3,083	11.1	18.7	40 " " 50
50 " " 60	1,461	9	44	630	783	108	255	159	3,449	12.4	31.1	50 " " 60
60 " " 70	1,479	10	50	383	496	172	275	125	2,990	10.7	41.8	60 " " 70
70 " " 80	1,561	13	44	410	314	217	151	96	2,806	10.1	51.9	70 " " 80
80 " " 90	1,691	36	24	627	238	167	53	147	2,983	10.7	62.6	80 " " 90
90 " " 100	1,585	84	25	396	95	161	65	67	2,478	8.9	71.5	90 " " 100
100 " " 110	1,291	74	48	593	50	136	97	62	2,351	8.5	80.0	100 " " 110
110 " " 120	1,017	152	29	160	35	101	69	75	1,638	5.9	85.9	110 " " 120
120 " " 130	890	112	56	92	23	98	29	18	1,318	4.7	90.6	120 " " 130
130 " " 140	672	57	34	39	14	101	3‡‡	16	936	3.3	93.9	130 " " 140
140 " " 150	384	27	16	48	11	45		17	548	2.0	95.9	140 " " 150
150 " " 160	538§	3	73	71	5	30		2	988§§	4.1§§	100.0	150 " " 160
160 " " 170			40	58	4	23		9				160 " " 170
170 " " 180			49		3	29††		6				170 " " 180
180 " " 190			8		2			5				180 " " 190
190 " " 200			6		1**			5				190 " " 200
200 " " 210			8					—				200 " " 210
210 " over			4¶					6				210 " over
TOTALS	13,656	581	566	3,641	4,688	1,565	1,145	1,868	27,710	100.0		TOTALS

* The distribution excludes agricultural and governmental employees, professionals and domestic servants. All employees are included except in manufacturing, mining and construction in these cases only wage earners are included.

† The mining distribution is gross average hourly earnings; all others are straight-time hourly rates.

‡ Most of the observations in this interval lie close to its upper limit.

§ Includes all persons over $1.50.

¶ Includes all persons over $2.10.

** Includes all persons over $1.90.

†† Includes all persons over $1.70.

‡‡ Includes all persons over $1.30.

§§ Includes all persons over $1.50.

tions because they indicate shifts of workers from low to high positions in the wage scale or vice versa. Therefore, it should be kept in mind that the component distributions of the manufacturing distribution are restricted by the skewness obtaining in their lines during the period 1939–1942.

However, that restriction is not as damaging in this case as it might be in another. The shape of a composite distribution like that for manufacturing depends upon (a) the shape of the constituent distributions and (b) the weights assigned to them. Due to the fact that there is much variation in shape from industry to industry, changes in weighting are likely to be a more important determinant of the shape of the composite distribution than any likely short-run changes in the shapes of the constituent distributions. The weights used were the number of wage earners employed in the various major industry groups on the dates considered. Inasmuch as these data are quite reliable, the manufacturing distribution is likely to give a fairly good representation of the wage structure despite the restriction which has been noted with respect to the skewness of the constituent distributions.

Furthermore that restriction is not a very serious one. The shapes of the constituent distributions result from the occupational differentials within the industries and from the distribution of employees among the several occupations. The short-run rigidity of the structure of occupational differentials and the unlikelihood in the short-run of violent technological changes which would permit a new occupational distribution of employees tend toward a short-run perpetuation of whatever shape a wage distribution may have.

Opposing these basic resistances to changes are certain factors which tend to modify occupational differentials and the distribution of employees; the balance, during any period of time, of these factors against the basic resistances determines the extent to which a distribution changes. The most important factors which have operated to change the wage structure since 1939 are (1) general percentage and cents-per-hour increases which operate on the occupational differentials, and (2) the upgrading of old employees to different, higher paid jobs and the influx of new workers into the low-end jobs as industry expanded, which changes influence the occupational distribution of employees. A general percentage increase raises the arithmetic mean and the range but does not affect the skewness of the distribution. A general cents-per-hour increase shifts the curve bodily to the right; its range and skewness are unchanged but its arithmetic mean rises. The upgrading of old employees skews the curve to the left, i.e., diminishes the frequencies in the low

intervals and raises them in the high intervals. The arithmetic mean rises but the range is unaffected. The influx of new workers into the low-end jobs increases the frequencies in the low intervals, thereby lowering the mean and skewing the curve to the right, but not altering the range.

Most general increases in recent years have been on a cents-per-hour rather than a percentage basis. Consequently, the Myers-Bloch method, which is satisfactory for percentage changes, has probably distorted the distribution somewhat. It is difficult to determine how great a distortion has been introduced. Both types of general increase raise the mean and leave the skewness unchanged. The difference between them is that the range is increased in the case of a percentage increase and is not increased in case of a cents-per-hour increase. Therefore, the Myers-Bloch method which conforms to the percentage increase would spread the total frequency over too wide a range. Which intervals it has over- and under-loaded depends upon the relative magnitude of the equivalent cents and percentage increases. In a few cases where both methods have been employed, they have not led to widely divergent results. To the extent that this relationship prevails, the distribution, as presented, is valid as to changes affecting occupational differentials.

The components of the second category of factors, those which affect the occupational distribution of employees, operate in opposite directions: the first shifts the frequency from the low to the high intervals and the second increases the frequencies in the low intervals. If these movements occur simultaneously, as they have, they tend to offset one another and to leave the shape of the distribution unchanged; if they occur singly they must soon peter out, barring technological change, because of inability to utilize a disproportionate number of workers in any category. From now on, one would expect the second component to operate weakly because manufacturing employment appears to have reached its peak. However, in the period 1939 to 1944 there was a large increase in employment as well as much shifting to high-paid jobs. Therefore, the presumption is that the net effect of these two components of the second factor of change is not large and that the distribution, as presented, is valid as to changes in the occupational distribution of employees. Accordingly, it is likely that the manufacturing distribution presented is a tolerable approximation of the true distribution.

The mining distribution is based upon all mine payroll reports for January 1944 made to the Bureau of Labor Statistics and covers 372,400 employees in all branches of the industry. The class frequencies

were inflated to a total of 581,000, the number of wage earners in the industry in January 1944. Each reporting mine submits the total amount of its pay roll and the total man-hours worked. The first was divided by the second to secure the hourly figures from which the distribution was constructed. Consequently, the data include overtime pay which makes them gross average hourly earnings rather than rates. Also the distribution is not one of individual employee earnings but rather is one of plant averages of individual employee earnings. The consequence is that the range of the distribution is narrower than the true range and that the concentration of frequency is too great.

The distribution of construction workers was derived as follows: A 15 per cent sample was taken of federal government contractors. (These are required to file payrolls with BLS.) The sample was distributed geographically and with respect to types of construction by drawing it regionally as 15 per cent of contractors in each major type of construction. About 35,000 employees were covered and this sample was inflated to the total number of construction wage earners. The weakness in this procedure is that rates vary with the type of construction. The method employed imputes to all construction the same distribution by types which prevails for federal construction. However, since federal construction is a little more than half the total, and since average hourly earnings are close to federal and to those types of non-federal construction for which the data are available, the error involved is probably not great.

The railway distribution is based on data for January 1944 issued by the Interstate Commerce Commission. These data cover all employees of Class I steam railways,[3] and are presented in the form of straight-time hours and payrolls for each occupation. The latter were divided by the former to secure the hourly earnings figures from which the distribution was constructed. Inasmuch as the hourly earnings figures used are occupational averages, the range of the distribution is narrower than the true range and the frequency is too highly concentrated as in the case of the mining distribution where plant averages were used. The latter obliterates dispersion due to occupational differences and the former obliterates dispersion due to regional and individual differences.

The telephone distribution covers the Bell System Companies which constitute over 90 per cent of the industry. The data were compiled by the Federal Communications Commission and appear in "Statistics of the Communications Industry in the U. S."—1943. As tabulated by the

[3] Officers and a few categories of supervisory and technical employees, whose compensation was quoted by the day, were omitted from the distribution.

F.C.C., the distribution was in terms of weekly wages with class intervals which became progressively wider. Reduced to an hourly basis, the intervals became so wide above 60 cents per hour that it was necessary to break them up. The frequency was distributed in such a way as to smooth the descent of a curve which would otherwise have gone down in a step formation. The sum of the telephone and railway distributions was inflated by the factor of 2.28 to the total employment in the transportation, communication and public utility industries.

In the fields of retail and wholesale trade, finance and services, no comprehensive wage data have ever been gathered; in fact, until recently, there have not even been sample data. In April 1943 the BLS began to make Occupational Wage Rate studies of certain non-manufacturing industries, and frequency distributions have been built up from these data.[4] The use of some 1943 data imparts a downward bias to the distribution because, according to a recent BLS study, "Wartime Wage Movements and Urban Wage Rate Changes," rates rose from April 1943 to April 1944 by about 12 per cent in retail trade, 4 per cent in wholesale trade and 7 per cent in finance. However, an upward bias is introduced by the fact that in general the communities surveyed were the larger ones, where wage rates tend to be higher than in small towns. In the case of each industry included in the BLS studies, surveys were made in selected communities. These reports list, for a particular community, the number of people engaged in each important occupation of the industry in question together with their average hourly rates.[5] Within the communities surveyed, the coverage is frequently above 90 per cent and in no case examined did it fall below 60 per cent.

The coverage with respect to communities and lines of business is spotty.[6] Some lines are covered in one region and not in another. In some regions, few communities have been surveyed and in others many. In building a frequency distribution from these data one has figures for fewer lines of business than he would like to have and they are not as well covered geographically as he could desire. Therefore, he must make the assumption that the communities and lines of business used for the distribution typify the universe. The data were tabulated for all the non-manufacturing lines for which there were a reasonable

[4] The variation of the studies in respect to date from April 1943 to the present is a limitation which cannot be overcome because there is not an adequate number of studies as of any one date.

[5] The construction of distributions in these fields from average hourly rates narrows the range and dispersion, as it did in the case of mining and railroads, but not as much because within any single community the rates for particular occupations within the same industry do not vary greatly in general.

[6] The BLS made its Occupational Wage Rate studies chiefly as a service to the Regional War Labor Boards.

number of surveys in all regions of the country. In general, New York state data were used to typify the Middle Atlantic and New England states, Georgia for the Southeast, Texas for the Southwest, California for the Far West, Nebraska for the farm belt, and Ohio for the East North Central states. The choice of regionally typical states was not a free one; it was governed by availability of data as well as by considerations of representativeness. In some cases where greater representativeness or coverage could be secured by using states other than those listed above, that was done, but in general they proved to be the most satisfactory choice.

Frequency distributions were built up by states for each line of business tabulated. Because the number of non-manufacturing lines tabulated fell far short of the total number, the problem then arose of dividing the non-manufacturing lines into more or less homogeneous groups each of which could be typified by one of the lines for which data were available. For this purpose the United States Ceusus classifications were used.[7] In all of the service groups and in many of the retail trade groups, data were available for at least one line. In the case of apparel, furniture, automotive, lumber, hardware, filling stations, liquor stores, second-hand stores and other retail stores no figures were available. Therefore, it was necessary to construct estimated distributions for these groups. This is not as serious a limitation as it appears by counting groups because only about one-third of the retail employment is in the unrepresented categories.

Estimated distributions for the unrepresented groups were constructed in the following manner, suggested by the section above on manufacturing. There it was indicated that the shape of a distribution depends upon the occupational differentials and the distribution of employees among the several occupations. On a priori grounds one would expect lumber and hardware distributions to resemble in shape the wholesale distribution. In all three the bulk of the employees are relatively well paid salesmen who possess technical knowledge of the line and are in a position to advise customers. In all three there is a secondary concentration of warehouse, etc., employees at a lower wage level and all three have a small complement of bookkeepers, typists, etc., at another level. While the lumber and hardware distributions are similar in shape to the wholesale distribution, their averages are lower. Therefore, by the technique described in the manufacturing section, distribu-

[7] Retail trade: food, general merchandise, apparel, furniture, household and radio, automotive, filling stations, lumber and building materials, hardware, drug stores, eating and drinking places, liquor stores, second-hand stores, other retail stores. Services: business and repair services, personal services except domestic, amusement and recreational services.

tions for these two lines were constructed from the wholesale distribution (described later) such that they have the shape of the wholesale distribution but the averages appropriate to the hardware and lumber groups. By the same procedure distributions for the apparel, furniture and automotive groups were estimated from the known department store distribution. The latter has a larger percentage of inexperienced, low-paid clerks than the others but in most respects it is similar to them. All four use incentive payment systems. They all have a concentration of relatively well-paid specialty salesmen and another lower concentration of stockboys, typists, inexperienced salespeople and the like. In the case of the second-hand stores, other retail stores and filling stations the techniques used above could not be employed because neither distributions nor averages were available. These groups have the same sort of structure as grocery stores: a very few skilled, higher paid people and a host of low paid, unskilled clerks and attendants. Limited observation indicates that the earnings of workers in these establishments approximate those of grocery employees. Therefore, as an estimate, it was assumed that the known grocery distribution could typify these groups in addition to the food group.

The next step was to weight the six state distributions for each line of business tabulated to reflect the relative importance in the several regions of the groups typified by the lines in question.[8] Then the state distributions for each line were added to yield national distributions and these were inflated to the January 1944 employment in the groups they were used to typify.[9] Finally the inflated group distributions were added to obtain totals for retail trade, services, and finance, insurance and real estate.

The frequency distribution for individual lines of business from which the totals were built up are shown in Table III. The finance, insurance and real estate distribution is based on a 13,000 employee sample drawn from banks and insurance carriers. These concerns employ over half the employees of the group. The data for wholesaling were so meager that they were not broken down by lines. They are chiefly for grocery wholesaling except in New York where a number of other lines were also covered. The sample included 10,000 employees who constitute about 1 per cent of the total number. For these reasons it was felt that

[8] Data from the United States Census (1940) showing the number of wage and salary workers in each region and group were used as weights.

[9] Current employment data, which are compiled by the BLS, are available only for large groups, e.g. finance, services and miscellaneous. Therefore, it was necessary to estimate the January 1944 employment in the narrower industry groups used in the study by reconciling the BLS large group total for 1940 with the United States Census data for that year, which is broken down, and then applying to the current BLS total the percentage breakdown from the 1940 census.

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the resulting distribution might approximate fairly well the shape of the true wholesale distribution but that it might not be at the proper level. The fact that its mean was about 20 cents below that calculated by the BLS from its sample of wholesalers who submit hours and wage bill data seemed to confirm this hypothesis, particularly in view of the fact that the BLS average for wholesaling and that based on census data had been very close on the last census date. Therefore, the frequency distribution resulting from the Occupational Wage Rate studies was adjusted to the BLS average for wholesaling by the method already described.

TABLE III
LINES OF BUSINESS UPON WHICH THE RETAIL TRADE AND SERVICES DISTRIBUTIONS ARE BASED

Line of business	No. of employees in sample	No. in sample as % of employees in line	Group typified by this line	Employment in line as % of employment in group
Department stores	27,000	5	Genl. mdse. dry goods & dept. stores	87
Grocery stores	25,000	4	Food, liquor, second-hand stores, other retail stores & filling stations	34
Restaurants	23,000	4	Eating & drinking places	68
Drug stores	11,000	6	Drug stores	100
Variety stores	135,000	13	Variety stores	100
Auto repair shops	7,400	3	Business & repair services	61
Hotels	17,000	5	Personal services, except domestic	73
Laundries & cleaning & dyeing plants	18,000	5		
Motion picture	7,700	6	Amusement & recreational services	33

Clearly, a frequency distribution which has been constructed by the means outlined cannot be regarded as more than an estimate. It is presented in the hope that pending the availability of more satisfactory basic data it may serve a useful purpose despite the reservations attached to it. The Occupational Wage Rate studies which supplied much of the raw data for this investigation are being continued, and after a time they should make possible more rigorous inquiries than the present one.

A SIMPLIFIED CALCULATION OF THE POTENCY OF PENICILLIN AND OTHER DRUGS ASSAYED BIOLOGICALLY WITH A GRADED RESPONSE

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The relative potency of a drug or poison is frequently determined with a biological indicator which gives a graded response. When the response is a linear function of the logarithm of the dose within a useful range, experiments may be planned conveniently in factorial designs and evaluated through the analysis of variance [4]. More direct calculations for potency in the simplest of these designs have been suggested recently in two independent reports [6], [10]. A modified analysis has the advantage of leading directly to easy estimates of both relative potency and its standard error [2]. This procedure has been used in a U.S.P. collaborative study of the penicillin assay and is developed here in more detail.

Assays to which the present calculations apply are those with two doses of each of two preparations, referred to as "standard" and "unknown." The ratio of the larger to the smaller dose of the unknown, U, must always be the same as in the standard, S, so that $U_2:U_1=S_2:S_1$. The two doses of the unknown are selected so that their expected potencies will be the same as those of the standard, as nearly as this can be determined in advance. The assumed potency is then corrected by biological assay. By isolating the differences for each individual degree of freedom of direct interest to the experimenter, the potency of an unknown and its standard error can be computed with a minimum of arithmetic from such 2×2 factorial designs.

As a further restriction the experiment must be arranged in complete sets, each containing all four doses. These sets are then repeated until the results have the required precision. A set may consist of four successive reactions in the same animal, four litter mates of the same sex, four groups of animals tested at the same time or other groupings of similar units. Within each set the four doses are assigned in a random order, one to each unit. Differences between groups of four are segregated from the estimate of potency and of its error, but are not measured directly.

Basic data from a typical assay.—The method may be illustrated by an assay of histamine based upon the contraction of a section of guinea

pig gut as reported by Schild [9]. The tissue was immersed successively in two different concentrations of the standard and of an unknown preparation. The muscle reacted to each solution so that the height of contraction as recorded on the kymograph was a linear function of the log-concentration of histamine.

Successive contractions, however, tended to decrease in height, quite apart from the concentration in which the muscle was immersed. This change in the inherent capacity of the muscle was balanced by grouping successive contractions into sets of four representing two doses of the standard and two doses of the unknown. To give each concentration an equal chance of being tested at the beginning or end of a set, their order within sets was randomized.

As is customary in testing a new procedure, the unknown was here a known concentration of the standard. Hence the accuracy as well as the precision of the assay could be measured objectively. The original heights of response in one-half millimeters are shown in the left side of Table I.

TABLE I
ASSAY OF HISTAMINE

Set No.	Height of contraction for				$D_1 = U_3 - S_3$	$D_2 = U_4 - S_4$	$D_3 = U_3 - U_1$	$D_4 = S_3 - S_1$	$y_1 = D_1 + D_2$	$y_2 = D_3 + D_4$	$y_3 = D_1 - D_2$
	U_3	U_4	S_3	S_4							
1	131	103	122	89	9	14	28	33	23	61	− 5
2	132	104	122	92	10	12	28	30	22	58	− 2
3	136	87	118	84	18	3	49	34	21	83	15
4	112	74	110	66	2	8	38	44	10	82	− 6
5	106	73	98	50	8	23	33	48	31	81	−15
								Total	$107 = T_1$	$365 = T_2$	$-13 = T_3$

The first step in the analysis is to compute four differences from the four observations of each set, as shown in the second part of Table I. The successive differences are those of the unknown minus the standard at the high (D_1) and at the low (D_2) dosage levels and of the high minus the low dose for the unknown (D_3) and for the standard (D_4). These initial differences are then used to obtain the basic computing units, y. The values for $y_1 = D_1 + D_2$ total the effect of the difference between the two preparations while those for $y_2 = D_3 + D_4$ total the effect of the difference between the two dosage levels. The differences $y_3 = D_1 - D_2 = D_3 - D_4$ test whether the dosage-response curves for standard and unknown are parallel. Computing y_3 in two ways checks the correctness of the original differences. The y's for each set are the

orthogonal differences from the standard 2×2 factorial design [4]. They are summed to obtain T_1, T_2 and T_3 respectively, as shown in Table I.

Equations for computing relative potency and its standard error.—The potency assigned to the unknown in the course of an assay is corrected from totals such as in the lower part of Table I. The average difference in response between the standard and the unknown for N sets is $T_1/2N$. This difference is converted to units of log-dose by dividing by the average slope of the curve relating response to log-dose (Equation 3). Hence, the amount of the unknown assumed to have the same potency as the standard is estimated to have a relative log-potency of

$$M' = \frac{IT_1}{T_2}, \tag{1}$$

where I is the logarithm of the dosage interval or of the ratio of the high dose to the low dose for both standard and unknown. The potency assigned to the unknown in preparing the test doses U_1 and U_2 is then corrected, by computing

$$M = \log \text{ (assumed unitage or potency)} + M'. \tag{2}$$

The antilogarithm of M is the most probable estimate of the potency of the unknown for a single unit assay.

The precision of an assay is no greater than that shown by its standard error, s_M, and may be considerably less. Some factors are constant within but not between assays, such as the initial stock solutions and details of technique which differ with the experimenter or the laboratory. These do not appear in the computed s_M although their importance is judged by comparison with the standard errors of individual assays. Before computing s_M, three other values are determined from the y's and their totals. These are the combined slope (b) of the dosage-reponse curves for standard and unknown, the standard deviation (s) for a single observation in terms of the response, and the ratio (λ) of s to b or the standard deviation converted to units of log-dose.

With only two doses of the standard and of unknown, the slope may be computed by dividing the average increase in y due to a difference in dose, $T_2/2N$, by the difference in the log-dose (I), so that

$$b = \frac{T_2}{2IN}, \tag{3}$$

where N is the number of sets or groups in the assay. The standard

deviation is estimated from the variation of the y_1's, y_2's and y_3's about their respective means. These three components are assumed to represent different samplings from the "same universe" of variation, which are combined into a single more reliable estimate than could be obtained from any one component. In terms of a single response (not of a difference) the best estimate of the population standard deviation is given by the equation

$$s = \sqrt{\frac{S(y^2) - (T_1^2 + T_2^2 + T_3^2)/N}{12(N-1)}}, \tag{4}$$

where y refers to all individual values of y_1, y_2 and y_3, and $S(y^2)$ is the sum of their squares. With a calculating machine Equation 4 can be solved directly without recording any intermediate steps. In its absence it is useful to write down the squares of the y's and of the T's from any convenient table of squares. The standard deviation in the response is then divided by the slope to convert it from units of response (y) to units of log-dose (x) and we have

$$\lambda = \frac{s}{b}. \tag{5}$$

The smaller this term, the more sensitive is the method of assay for detecting differences in potency. As a measure of the inherent precision of the technique, λ should be relatively stable from one test to another.

The above statistics are of direct interest in critical studies of an assay technique but they are used immediately in a convenient equation for the standard error (s_M) of the log-ratio of potencies. As orthogonal terms, the totals T_1 and T_2 in Equation 1 are assumed to be independent of each other. The variance of M' may then be written as

$$V\left(\frac{IT_1}{T_2}\right) = \frac{I^2T_1^2}{T_2^2}\left\{\frac{V(T_1)}{T_1^2} + \frac{V(T_2)}{T_2^2}\right\},$$

where V stands for the variance of the terms in parentheses. Substituting $4Ns^2$ for the variance of both T_1 and T_2 and $1/Nb^2$ for $4I^2N/T_2^2$, a simple algebraic transformation gives the equation[1]

$$s_M = \lambda\sqrt{\frac{1}{N}\left\{1 + \frac{T_1^2}{T_2^2}\right\}}. \tag{6}$$

[1] Equation 6 has been derived in several ways. The starting point for that given here is based upon a suggestion from Miss Lila Knudsen of the U. S. Food and Drug Administration. Where the population standard deviation for y_1 is known to differ from that for y_2, Equation 4 does not hold and Equation 6 necessarily takes another form.

The more nearly equipotent the concentrations of the unknown and of the standard used in carrying out the assay, the smaller is T_1 and the more nearly s_M approaches a minimum.

$M \pm s_M$ are computed in logarithms, so that critical tests of statistical significance should be made in the same terms. As noted by several workers, most recently by Finney [6], the formula for s_M is itself an average of unequal lower and upper limits, which may differ appreciably unless the ratio s^2/T_2 is a small number. When values which are approximately equidistant in logarithms are converted to original units, the lower confidence or fiducial limits are necessarily nearer to the most probable value than the upper limits. If one is willing to neglect this discrepancy, an average standard error may be computed as

$$\text{standard error of potency} = 2.30 s_M \text{ (antilog } M). \qquad (7)$$

Example.—These equations may now be applied to the histamine assay in Table I. Since the unknown is here assumed to have the same potency as the standard, the logarithm of relative potency is given directly by M'. Substituting in Equation 1 the values from Table I, with $I = 0.3010$, $M = M' = 0.3010 \times 107/365 = 0.08824$. The antilog of M is 1.225, so that the unknown is assayed as 122.5 per cent as potent as the standard.

The standard error of this estimate requires three other values. The slope of the dosage-response curve is given by Equation 3 as $b = 365/(2 \times 0.3010 \times 5) = 121.3$ and the standard deviation of a single response by Equation 4 as $s = \sqrt{\dfrac{30289 - 144843/5}{12(5-1)}} = 5.245$. The ratio of these two terms gives $\lambda = 5.245/121.3 = 0.04324$. In comparison with other biological assays [3], λ indicates a relatively sensitive technique.

Substituting in Equation 6, $s_M = 0.04324\sqrt{1/5\{1 + 107^2/365^2\}} = 0.02015$. From Equation 7, the approximate standard error of percentage potency is $2.30 \times 0.02015 \times 122.5 = 5.7$ per cent. Hence, the "unknown" histamine has an assayed potency 122.5 ± 5.7 per cent that of the standard. Since its true potency is given by Schild as 125 per cent, the accuracy of the assay was well within the estimate of its precision.

Computation when $I = 0.5$.—The calculation may be further simplified if the experimenter will design his assays so that the ratio between doses is $U_2 = 3.16\ U_1$ and $S_2 = 3.16\ S_1$, giving a log-ratio of $I = 0.500$. This modification was first proposed by Dr. Lloyd C. Miller, to whom I am indebted for the data in Table II. It has been used successfully

in the penicillin assay at the Winthrop Chemical Co., Inc., for many months [8]. With this change Equation 1 becomes

$$M' = \frac{T_1}{2T_2} \tag{1a}$$

and Equation 3 becomes

$$b = \frac{T_2}{N} \cdot \tag{3a}$$

The other formulae are not affected.

The procedure may be illustrated by the data in Table II from two routine plate assays of the same sample of penicillin by the Oxford cup technique. Both S_2 and U_2 were prepared initially to contain a known and an assumed concentration respectively of 2.0 U/cc. The weaker dilutions were obtained by adding 2.31 cc. of S_2 and of U_2 to vessels containing 5.00 cc. of buffer solution. The dosage interval in logarithms for the resulting test solutions was $I = 0.500$.

TABLE II
CYLINDER-PLATE ASSAY OF PENICILLIN

Plate No.	Diameter in mm. for 1st assay				Diameter in mm. for 2nd assay			
	U_2	U_1	S_2	S_1	U_2	U_1	S_2	S_1
1	25.8	20.8	25.6	20.4	26.0	21.0	25.4	20.6
2	25.8	21.0	25.2	20.4	26.0	20.8	25.4	20.2
3	25.4	20.4	24.8	20.0	25.6	20.8	25.2	20.2
4	25.8	20.8	25.2	20.4	25.8	20.8	25.2	20.4
Total	$T_1 = 3.8$ $T_2 = 39.4$ $T_3 = 0.2$				$T_1 = 4.2$ $T_2 = 39.8$ $T_3 = 0.2$			

In the present assay the unknown was assumed to have a potency of 400 Oxford units per milligram. Solving with the values in the first assay of Table II, we find that $b = 9.85$, $s = 0.1167$, $\lambda = 0.01185$, $M' = 0.0482 \pm 0.0060$, and by Equation 2, $M = 2.6503 \pm 0.0060$. From the anti-log of M, the unknown had an assayed potency of 447.0 ± 6.2 U/mg. This agreed well with the second assay of the same preparation, which gave 451.7 ± 5.6 U/mg.

Test for validity.—In the above procedure it is assumed that the standard and the unknown are qualitatively alike and that the doses fall on a part of the dosage-response curve where the response is essentially a linear function of the log-dose. If slopes computed separately for the standard and the unknown were to differ appreciably from

parallelism, one or both of these assumptions would be invalidated. Hence, the test for the parallelism of the dosage-response curves checks the validity of the assay. It is computed from the ratio of T_3 to its standard error, giving

$$t = \frac{T_3}{2s\sqrt{N}}, \tag{8}$$

where t is that in the t-test for significance. The observed t is referred to a suitable table [7] with $3(N-1)$ degrees of freedom. If it exceeds the value for $P=0.05$ or in repeated assays is persistently close to that value, the assumption of qualitative equivalence should be questioned or the dosage range revised.

The test may be illustrated with the data in Tables I and II. For the histamine assay, $t=13/(2\times5.245\times\sqrt{5})=0.55$ with $3\times4=12$ degrees of freedom. The probability that a t of this magnitude could occur by chance is $P=0.6$, so that here there is no evidence of diverging dosage-response curves for standard and unknown. The corresponding t's for the two penicillin assays were 0.43 and 0.47 respectively with 9 degrees of freedom, neither showing any lack of parallelism.

Analysis of multiple assays.—The above technique provides an estimate of potency and its standard error from the data of an individual experiment. Since relatively few observations are involved, these depend upon estimates of b and s which are necessarily less stable than if based upon larger numbers. Frequently, however, similar assays are carried out together or repeated routinely. Under these conditions both the slope (b) and the standard deviation (s) of the individual tests should be compared. The variation between tests may fall well within the sampling error in most or all assays for a given day, week or longer period, as has been observed with penicillin. The slopes can be compared readily by the analysis of variance and the standard deviations by the χ^2 test for the homogeneity of a series of variances, both standard techniques.

Occasionally the standard deviation is correlated positively with the slope, so that λ may be relatively stable even though s and b vary significantly. This seems to be true, for example, in the histamine assays reported by Schild [9]. For determining the agreement between different estimates of λ, the standard error of λ may be computed as

$$s_\lambda = \lambda\sqrt{\frac{1}{6(N-1)} + \frac{\lambda^2}{NI^2}}. \tag{9}$$

The homogeneity of a series of statistics can be tested by χ^2 when their standard errors are known [1].

An assay technique has not been fully standardized until the variability in s and b or λ is within the limits of random sampling. The procedure is then said to be in a state of statistical control, which brings substantial advantages to the experimenter. The agreement of individual assays with past experience is checked graphically by a control chart technique, as will be described elsewhere for the cylinder-plate assays of penicillin [5]. If a given assay meets this requirement, the calculation of potency is further simplified. Since the standard error depends only upon the number of sets (N) it need not be computed individually for each assay.

Cases arise, however, intermediate between the individual test and the stabilized routine assay with its control charts. It is desirable to combine standard deviations and slopes when their estimated values in two or more similar assays agree within the sampling error. The individual variances (s^2) provide an improved estimate of the standard deviation by the usual formula

$$s_c = \sqrt{\frac{S(ns^2)}{S(n)}}, \tag{10}$$

where $n=3(N-1)$ or the degrees of freedom in each individual estimate. If the slopes are parallel and I is constant in tests with the same s_c, their combined value may be computed as

$$b_c = \frac{S(T_2)}{2IS(N)}. \tag{11}$$

Then the relative log-potency of each assay is determined from its observed T_1 as

$$M' = \frac{T_1}{2Nb_c}. \tag{12}$$

The standard error of the M' obtained with the pooled estimate is

$$s_M = \lambda_c \sqrt{\frac{1}{N}\left\{1 + \frac{S(N)}{N}\left(\frac{T_1}{S(T_2)}\right)^2\right\}}, \tag{13}$$

where $\lambda_c = s_c/b_c$, N is the number of sets in an individual assay and $S(N)$ the number in the whole series to which it belongs. When several values

of M are to be compared or combined, Equation 13 leads to more precise results than Equation 6.

Summary.—An easy calculation of relative potency and its error is described for biological assays that meet certain experimental requirements. These are (1) a graded response, some function of which is linear over a working range of log-dose, (2) arrangement of the individual reactions in relatively homogeneous sets of four, (3) testing within each set two different doses of both a standard and an unknown in a random order and (4) use of the same ratio between the two doses of each preparation.

Acknowledgment.—I am indebted to Professors A. Wald and W. G. Cochran, who have very kindly checked the above method with especial reference to Equation 6.

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A METHOD OF ANALYSIS OF FAMILY COMPOSITION AND INCOME

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Billions of dollars have been distributed in the past twelve years on the basis of "need" in low income families. The obverse of the term "need" may be designated as "adequacy." Theoretically, the need of a particular family is determined by subtracting its resources from a more or less defined yardstick of adequacy. Likewise, many wage disputes revolve around the concept of requirements for adequate family support. This concept also entered to a large extent into the determination of the scale of allowances for the families of the armed forces, and, presumably, will influence the allocation of commodities in the post-war international relief programs. In spite of the wide administrative use of this concept, much more research is needed before sufficient precision can be obtained in scales designed to measure adequacy for individuals of different ages, sexes, and in different regions.

There are two general classes of yardsticks which, for convenience, we shall designate the "theoretical" and the "average." The theoretical approach consists in defining a standard of living in terms of specific goods and services considered as necessary for particular ages or classes of people. These goods and services may be priced at various times and places and the cost compared to the income available to various types of families or to a particular family.

The average approach consists of an effort to measure the relationship of the actual incomes of various types of families, using as a yardstick the median per capita for the Nation, region, or state under consideration. In effect, this method compares the income available for the members of any particular type of family with the actual income below which half the families get along.

A method of developing the average approach will be discussed in this article. The application of the method will first be described without reservations as to accuracy. The assumptions involved and the shortcomings in the data will be pointed out at the end of the article.

Direct comparison of family incomes is, of course, not very revealing because families vary in composition and the needs of adults and children are not equivalent. Incomes should first be reduced to a per capita basis, and the various types of family members should be assigned dif-

* The author is indebted to Jacob Fisher, Franklin Aaronson and Martin L. Marimont, Bureau of Research and Statistics, Social Security Board, for assistance in refining methodology.

ferent per capita weights. For the purpose of this yardstick, adults (over 18 years of age) will be assigned one full unit and children (under 18 years of age) will be assigned one-half unit in determining family unit composition.

Family composition is tabulated in the Census of 1940 in considerably more detail than in any previous Census and, for some types of families and geographic divisions, income is cross-tabulated by type of family. Average family composition for all private families is available directly from Table 11, "Population—Characteristics by Age," for the United States as a whole and for each state in Table 13 of the state tabulation of characteristics by age. These tables yield the following averages by residence of family (after excluding servants and lodgers):

Total individuals
Heads of families and their wives
Children under 18
"Extra" adults

This composition may be reduced to family units by weighting the children under 18 one-half, the adults one, and summing the result. Income distributions by regions are available in Table 9, "Population—Family Wage or Salary Income," and for states and cities over 100,000 in Table 34, "Population and Housing—Families—General Characteristics," and for cities over 100,000 in Table 59 of the same volume. Income by type of family for cities is, however, not published.

The division of the median family income of a state, region, or city by the family units in the average household composition will yield the family units of the median income for all families in the area under consideration. Such calculations should be limited to those families reporting wage and salary income *without* other income, since those families *with* other income do not have the "other" income included in their total. For this group the published figure is only a partial family income. Of the 35 million wage or salary earning families in the United States, about 16 million are non-farm families with wage or salary income only. If it is desired to analyze these incomes by frequency distributions or according to various family types, it is necessary to make computations involving a number of different tables in various volumes of the Census, and the note on computation at the end of this article will serve as guide for locating and processing these data.

The family units for the types of families with wage or salary income only which result from such computation are shown in Table I.

The constant rise in the number of adults and decline in number of children as income increases causes an increase in average number

TABLE I

AVERAGE PERSONS IN UNITED STATES FAMILIES, WITH WAGE OR SALARY INCOME ONLY, URBAN AND RURAL NON-FARM COMBINED, BY FAMILY UNITS AND INCOME

(1) Income	(2) Total persons	(3) Adults	(4) Children under 18	(5) Family units
All Families	3.460	2.336	1.124	2.898
$1–$499	3.146	1.987	1.159	2.566
$500–$999	3.354	2.142	1.212	2.748
$1,000–$1,499	3.419	2.232	1.187	2.825
$1,500–$1,999	3.465	2.326	1.139	2.895
$2,000–$2,499	3.545	2.489	1.056	3.017
$2,500–$2,999	3.706	2.746	.960	3.226
$3,000–$4,999	3.943	3.049	.894	3.496
$5,000 and over	3.978	3.062	.916	3.520

of family units per family in each successive step in the income distribution. Similar computation for states by income steps is possible by adjusting the state averages of adults and children in all families to families with wage or salary income without other income with the same degree of difference as is shown in the region; then distributing this total by income steps in the same degree of variation as shown in the region. Computation of states by family types requires a special tabulation from the Census similar to Table 9, "Wages or Salary Income, 1939, for the United States."

Comparisons of medians of per capita wage or salary incomes by types of family from Table 9, "Population—Families—Wage or Salary Income, 1939," cited above, are shown in Table II.

With this "average" method of measuring adequacy in mind, it is possible to distinguish between it and the "theoretical" approach. In 1944 the Textile Workers' Union of America, in cooperation with the Bureau of Labor Statistics, priced an "emergency" budget in two North Carolina textile towns. This budget includes commodities and services originally selected by the WPA as the basic minimum needs of relief families but was modified with respect to the food items to adjust for more recent nutritional standards. It includes only low quality goods in limited amounts and is conceded to afford a level of living much below the needs of the average family for minimum comfort and satisfaction. The cost of the items in this budget in 1944 was found to be $1,413 in High Point, North Carolina, and $1,369 in Henderson, North Carolina, or roughly $1,400 in towns of this category. On the basis of 1939 prices, this is equivalent to $1,110 (allowing for an increase of 26 per cent in the cost of living from 1939 to 1944).

TABLE II

FAMILY UNIT INCOMES OF FAMILIES WITH WAGE OR SALARY INCOME ONLY, BY TYPES AND NUMBER OF CHILDREN UNDER 18 YEARS OF AGE. URBAN AND RURAL NON-FARM FAMILIES, 1939

Type of family	United States			Southern region		
	Median family income	Family units	Median income per unit	Median family income	Family units	Median income per unit
All families	$1,380	2.92	$474	$ 965	2.92	$330
Male head with wife:						
No children	1,563	2.46	635	1,144	2.42	473
1 child	1,480	2.96	500	1,164	2.92	400
2 children	1,475	3.46	426	1,133	3.42	331
3 or more children	1,223	4.46	274	885	4.40	201
Male head other:						
No children	964	1.57	614	659	1.53	430
1 child	1,304	2.07	630	832	1.93	431
2 children	1,250	2.57	486	829	2.53	328
3 or more children	1,100	3.53	312	735	3.47	212
Female head:						
No children	986	1.96	503	568	1.90	300
1 child	840	2.46	341	501	2.40	209
2 children	774	2.96	261	472	2.90	166
3 or more children	588	3.90	151	410	3.84	107

Since this budget is designed to support, at the emergency level, a man, his wife, one child 7 to 9 years of age, and one child 13 to 15 years of age, it represents roughly $3\frac{1}{4}$ family units (counting the adults as one unit each, the child 7 to 9 as one-half unit, and the older child as three-fourths of a unit). The unit equivalent cost of the emergency budget was about $341 as against the North Carolina equivalent median family income of $308. This comparison, as crude as it is, indicates that families living below the median level in North Carolina are not provided with the goods and services which are needed for the kind of opportunities for children required by a sound democracy.

This indicates clearly the dilemma in choosing between the two methods of determining adequacy for a particular family. The person who is genuinely interested in improvement will want to measure adequacy not merely by the "emergency" level budget but at some higher level more nearly representing desirable standards of comfort. Yet, when an emergency budget is priced in many areas, its cost is found to be above the level at which more than half of the families actually get along. On the other hand, hard-boiled administrators and legislators who do not

believe in "pampering" the needy will not subscribe to a level of adequacy which is above the customary living level of a large segment of the self-supporting population. For them the concept of average adequacy may have more realistic validity.

As has been shown in the preceding paragraph, however, it is possible by constant and widespread pricing of "theoretical" budgets to compare the two yardsticks and enable planners and administrators of a particular program to choose one or the other or a compromise between the two.

Students of family composition and income distribution will recognize immediately that the foregoing discussion has passed over some rather broad assumptions with the result that the conclusions are approximate at best.

The assignment of one unit to adults and one-half unit to children is in itself debatable. As indicated at the outset, much more research is needed on this point. Since, however, the conversion to family units is one of the final steps in this method, the analysts with more refined scales available may assign different weights to suit their purposes.[1] W. S. Woytinsky, (*Earnings and Social Security in the United States*, pages 233–236) in using a similar method, comments that its chief virtue is in its simplicity. There will always be much subjective judgment involved in allocating consumer weights to persons of various ages, since at a given income level some parents will sacrifice their own needs to provide for the children, and others will follow the opposite course. Likewise, "pooled" expenditures, such as for rent, heat, light and furnishing, have to be arbitrarily allocated among family members.

Accuracy of income reporting is also doubtful. Any approach to family income by enumeration is as fallible as human memory. Some cross checks between wages and salaries as reported to the Census and those reported by employers to the Treasury as social security tax returns indicate some under-statement in the Census. The extent to which this error is distributed by income classes should be the subject of further investigation, as this distribution of error after all is more important in comparisons than the actual amount of under-statement.

In fact, the errors involved in income reports and the method of tabulation which presents the data in broad steps of $500 in each step would lead to the conclusion that the crudities in income data would to a large extent mask any minor fluctuations which might arise from crudities in the scale of adult equivalents used.

A second drawback to the income data is the fact that they are the

[1] The use of family units in income is similar to the use of consumer units in measuring expenditures.

cross-section picture as of 1939 and projections for subsequent years would involve assumptions as to the change in income distribution.

Both of these defects in the application of this method to incomes reported to the Census could be overcome to a large extent by a more detailed presentation by the Treasury Department of analyses of incomes reported for taxation together with exemptions claimed for minor dependents. Such data will relate to individual and not to family incomes, but since they should be available annually, they will afford indices of change of income distribution from year to year.

If the method of reducing income to family unit income is applied to states, it must be remembered that the income-family composition data are based on a sample and that the final results are finely subdivided. Hence, in the smaller cells of the table considerable sampling errors may occur. For instance, non-farm families with wage or salary income only and with male head, no wife, and three or more children, constitute only about .0014 of the total families, and, if such a small category is further distributed by income frequency or color, unreliability may occur.

There are also certain assumptions underlying the calculations of family composition. The subdivision of families into those with 0, 1, 2, and 3 or more children necessitates the assumption that the number of extra adults is the same in these four types of families. The assignment of the same unit value to all children and the same to all adults assumes that there are no economies in buying and planning which are available to the larger families but not to families with only one or two children. It is also assumed that family composition as enumerated in 1940 was approximately the same as in 1939—the year for which income data were secured.

There is likewise a mathematical difficulty involved in dividing median income by the arithmetic average size of family. This procedure yields the per capita equivalent for the family with the median income which is the general summary of the relationship between the income series and the family composition series. Several other alternatives for relating these series are possible. A median of per capita incomes is published by the Census under the designation of "median per capita income" and has been calculated by computing the average income of families of each size within each income step and computing the median of this array of per capita incomes. The difficulty of this method is that it assumes that the incomes within each step of the frequency distribution are distributed evenly around the midpoint of the step. The other difficulty is that such detailed calculation is not possible for types of families or for subdivisions of the total population.

A second possibility is the comparison of the estimated average income to the average size family. The difficulty with this method is that it involves estimating the amount of income which is earned by families in the $5,000 and over category, which amount was not enumerated by the Census.

Also, it is possible to compare the composition of the family in the median income step to the median income. This latter procedure does not yield results materially different from the one here proposed.

None of these methods of comparing the two series is entirely satisfactory. The most important consideration in making comparisons between types of families and areas is to use the same summary measure in both of the elements which are to be compared.

To summarize the foregoing statement of shortcomings in the data and methodology, it may be said that the measure which has been evolved is one of general relationship between family composition and income and is not suitable for the discrimination of small differences. The discrepancies in unit income equivalents, however, which appear in Table II are so wide, and similar comparisons between states in different regions so pronounced that the measure may be recommended to those who wish to make general comparisons of incomes on the basis of the number of people which the income supports.

The method proposed for analyzing family composition is useful by itself even if no attempt is made to relate it to income distribution. For this purpose the computation is greatly abbreviated and the result is subject to only minor errors. It provides accurate comparison by states, by residence, by family, and by age of the head of the family, of family composition in these various categories.

The utility of analysis of family composition without reference to size of income is indicated by Table III which shows the distribution of children and adults by residence and by type of family.

The non-farm wage or salary workers only comprise the industrial and white collar workers. The non-farm "other income" group is a miscellaneous residual. The farm "wage or salary income only" comprises the laborers in farm families and the "other income" group is for the most part composed of farm operators.

NOTE ON COMPUTING FAMILY COMPOSITION BY INCOME AND FAMILY TYPE

Step 1. If all non-farm families with wage or salary income only are to be analyzed, it is necessary to combine the family members in urban and rural non-farm families to obtain the total population in such families. As was pointed out in the text, this computation can

TABLE III

AVERAGE FAMILY COMPOSITION BY RESIDENCE AND BY FAMILY TYPE, UNITED STATES 1940*

Family type	Urban and rural non farm		Farm	
	Wage or salary income only	Other income	Wage or salary income only	Other income
Male head with wife				
Adults	2.458	2.554	2.531	2.790
Children	1.270	1.214	1.044	1.758
Male head, other status				
Adults	1.570	1.694	1.524	2.008
Children	.378	.319	.576	.562
Female head				
Adults	1.655	1.870	1.940	2.204
Children	.064	.558	1.342	1.085

* Composition is as of 1940; Income status as of 1939.

be made from Table 11, "Population—Characteristics by Age," for the United States and Table 13 of the state tabulations of characteristics by age for each state. It is necessary to subtract servants and lodgers from the total. Unfortunately, regional totals of this table by residence are not published, and it is necessary either to add up the states in a region or secure a special tabulation from the Census.

Step 2. From "Population—Families—Size of Family and Age of Head," Table 8 for the United States and Table 9 for regions, add together all persons in families of 1, 2, 3, 4, 5, and 6 members and subtract the total from the total obtained in Step 1 to obtain the number of persons in 7 or more person families in the whole non-farm population.

Step 3. To convert the number calculated in Step 2 into an average for families with wage or salary income only, calculate the percentage of all persons who are in 6-person families with wage or salary income only and apply this percentage to the total persons in families of 7 or more members. Reduce to an average. (Except for highly refined calculations, this step may be omitted and the average persons in 7-person families secured from Step 2 may be applied directly to the number of non-farm families with wage or salary income only. The error arising from this shorter process affects only the third decimal place of the number of adult equivalents. In view of the crudities in the income data into which adult equivalents are divided, the error is most negligible.)

Step 4. Reduce the number of members of 7-person families obtained in Step 3 to an average per family.

Step 5. Multiply this average by the number of 7-person families headed by a man and wife, by a man alone, or a woman alone.

Step 6. Multiply the same average by the number of 7-person families in each income step in each of the family types used in Step 5.

Step 7. The two preceding steps have yielded a distribution of the number of persons in 7-person families which can be added in each cell of the table to the actual number in families of 1, 2, 3, 4, 5, and 6 persons, the sum being the number of persons in each income step of each family type. These totals, divided by the number of families in the corresponding cell, yield the desired distribution of the average persons per family in each category. The distribution of average total persons by income steps for all types of families combined is shown in Column (2) of Table I in the text.

Step 8. Total children under 18 years of age were obtained in Step 1. Children in all families are distributed in Tables 5 and 6 of "Population—Families—Types of Families," except that as in case of the total number of persons there is an open-end category of 6 or more children and in order to distribute this number properly, a computation similar to Steps 2 through 6 is necessary, yielding the total number of children in all families with wage or salary income only. The number in 1 and 2 child families subtracted from this total yields the number in 3 or more child families. This can be reduced to an average.

Step 9. Families with 1, 2, and 3 or more children are distributed by family type and income steps for the United States and for regions in Table 9, "Population—Families—Wage or Salary Income, 1939." From this table, it is possible to calculate for each cell the number of the children in 1 and 2 child families. The average number in 3 or more child families times the number of such families in each cell yields the number of children in 3 or more child families which, combined with those in 1 and 2 child families, gives the total children in families in the cell. This calculation is only necessary if it is desired to analyze per capita incomes by type of family according to the number of children in the family as shown in Table II of the text.

Step 10. Average children under 18 years of age per family can be deducted from average total persons per family as calculated in Step 7 and the difference represents the average adults in the family. (Shown in Column (3) of Table I, text, by income steps.)

Step 11. Divide the average number of children by 2 and add to the average number of adults to secure the average family units per family.

Step 12. Divide median income of the categories under consideration by the average units per family to reduce total family income to family unit income.

DETERMINING SAMPLE SIZE

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One possible purpose of a marketing survey is to determine the strength of a potential market. Suppose that the sampler intends to build a plant, in order to enter the market. The scale of his plant will depend on his information about the market. A sample will furnish his information; thus it will determine the scale of plant.

The larger the sample, the more accurate its information. The better the information, the more profitable the plant will be. But enlarging the sample entails cost. Therefore there is need of a theoretical background for determining the optimum size of the sample.

Let each potential customer be considered a sub-market, with H_i a number representing the strength of the i^{th} sub-market. Let H_t be the strength of the whole market, consisting of m potential customers.[1] The sample of n will include n "H_i"s, and have a mean $\overline{H}'$.

In the market there is a standard deviation, σ_{H_i}, a measure of the dispersion of the "H_i"s, and a sample of n will have a standard deviation, σ_s.

On the basis of $\overline{H}'$ and σ', there is a probability[2] for each possible value of $\overline{H}$. A plant will be selected on the basis of the whole array of probabilities. Let α represent the size of the plant.

There will be some profit expectation per production period, determined by α and the probability array. On the basis of the sample of n, the net worth of the investment opportunity is the product of the profit expectation per period and the number of periods.

If the profit expectation can be raised, the net worth of the investment opportunity can be raised. The rise in net worth will be the value of the action raising the profit expectation. If the sampler can get an unbiased estimate of the change in net worth that will be caused by an action, the estimate can be considered the value of the action.[3] To decide whether to take the action, the sampler will compare its value with its cost.

The action to be discussed here is the addition of the $(n+1)^{th}$ item to the sample. If the sampler can decide whether to add the item, he has a method for determining the optimum size of sample.

[1] H_i and H_t are given more specific meanings on p. 499.

[2] For details, see p. 502.

[3] An unbiased estimate of a parameter is one that has no net tendency either to overstate or understate the parameter.

The economic setting of the problem must be assumed in detail, so that profit expectations can be computed. The assumptions are as follows:

1. All raw material enters the plant at one time, and all finished product emerges at one time. The intervening period will be called the production period.
2. The production period is fixed.
3. The sampler's planned action is that of selecting a scale of fixed equipment, α.
4. Whatever the value of α, the life of the equipment is a constant.
5. Fixed cost per production period is a constant multiple of α. Let the multiplier be C.
6. The plant is to produce only one product.
7. On a range $x=0$ to $x=D\alpha$ (where D is a constant and x is output per period) marginal production cost is a constant for any α. This assumption is in accord with the findings of factual studies.[4]
8. The maximum production is $D\alpha$. With a given plant, there must finally be an end to adding equipment and increasing the hours of work and the number of shifts. The element of unreality seems to lie not in positing an output limit, but in neglecting a marginal cost rise before the output limit is reached.
9. The marginal production cost curve can be reduced by increasing the size of the fixed equipment. Concretely, it will be assumed that marginal production cost is A/α, where A is a constant.[5] Certainly it is possible to substitute fixed and variable cost marginally at the time when the plant is built. If the function chosen should prove inappropriate, another could be substituted.

The foregoing assumptions have dealt with production conditions. The picture presented is essentially that of a break-even chart. The U shaped marginal production cost curve common in economic assumptions has been avoided, since apparently it is not prevalent. The break-even chart has not been popular among economists—perhaps because it gives the impression that unlimited extension of sales is desirable. The break-even chart must be modified to include selling facts. A marginal selling-cost curve must be drawn to indicate the cost of selling each additional item.

10. When additional units of an industrial product are to be sold to

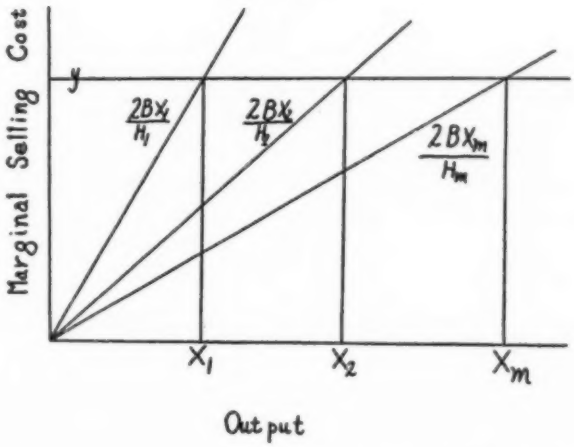
[4] E.g., Joel Dean, *Statistical Cost Functions in a Hosiery Mill*, Chicago University Studies in Bus. Adm. vol. 11, no. 4.

[5] The 8th and 9th assumptions together preclude separate variations in marginal production cost and maximum output.

a customer, the salesman must spend increasing increments of time surveying the customer's plant to discover additional uses for the product. Thus it is very reasonable to assume that the marginal selling cost curve is a rising line in each sub-market. The choice of function will depend on the indications given by the estimated marginal selling cost curves of the first n plants sampled. It will be assumed that the function is $2Bx/H_i$, where B is a constant. Pending the gathering of adequate information on the nature of selling cost curves, a straight line may reasonably be used as an approximation. H_i (the indicator of the strength of the sub-market) is here given a specific algebraic meaning.

11. Selling price is assumed known. Actually, the price and the scale of plant might be determined simultaneously. The analysis could be extended, though with some difficulty in manipulation, to cover the wider problem. To avoid unnecessary complication it will be supposed that industry custom sets the price.
12. The final assumption is that there is no subjective time discount. Introducing time discount would complicate the analysis to an extent out of proportion to the amount of realism gained.

CHART I



Before the assumed case is investigated, it may be useful to look at the economic adjustment that would be made if there were no uncertainty about selling conditions. Assume that there are m potential customers, each with an H_i. Chart I shows some of the marginal selling cost curves. It can be shown that the market parameter, H_t, is the sum

of the individual "H"s for the sub-markets. For the i^{th} customer, the common marginal selling cost level is $y = (2Bx_i/H_i)$. Total selling cost is

$$W = \frac{y}{2} \sum_1^m x_i. \tag{1}$$

Total sales are

$$x = \sum_1^m x_i. \tag{2}$$

For the whole market, marginal selling cost is

$$\frac{dW}{dx} = \frac{y}{2}. \tag{3}$$

Since

$$x_i = \frac{yH_i}{2B} \tag{4}$$

$$x = \frac{y}{2B} \sum_1^m H_i \tag{5}$$

or

$$y = \frac{2}{\sum_1^m H_i}. \tag{6}$$

Thus for the market curve, $\sum_1^m H_i$ may be replaced by H_t.

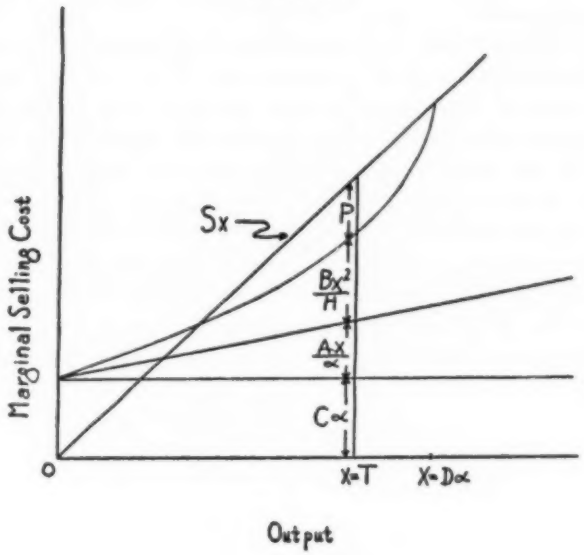
Suppose first that H_t is known. Let S be the selling price. Then profit will be

$$P = Sx - \frac{Ax}{\alpha} - \frac{Bx^2}{H_t} - C\alpha \quad (\text{for } x \leqq D\alpha). \tag{7}$$

In Chart II the elements into which total receipts are divided are indicated by bands. The maximum production is $D\alpha$, and the maximum profit is realized when $x = T$. In order to make the maximum profit, the business man would set $\partial P/\partial x = 0$ for any given α. Thus,

$$S - \frac{A}{\alpha} - \frac{2Bx}{H_t} = 0 \tag{8}$$

CHART II



or

$$x = \frac{H_t}{2B}\left(S - \frac{A}{\alpha}\right). \tag{9}$$

But profit must also be maximized with respect to α. Thus

$$\frac{\partial P}{\partial \alpha} = \frac{Ax}{\alpha^2} - C = 0. \tag{10}$$

When (10) is substituted into (7),

$$\frac{H_t\left(S - \frac{A}{\alpha}\right)^2}{2B\alpha^2} = C. \tag{11}$$

This is a cubic equation in α and can be solved readily. For example, if $A=1, B=5, C=4, H_t=10, S=5$; then $\alpha=1, x=4, P=4$. If the number of production periods is 20, the investment opportunity is worth 80.

But instead of a known H_t there is a probability distribution of possible "H"s. The estimate of H_t from the sample of n is $m\overline{H}'=H'$. The distribution of "H'"s has the same shape as the distribution of sample means. $\sigma_{H'}=m\cdot\sigma_{\overline{H}'}$. The distribution of possible universe sums H

around H' is the same as the distribution of possible "H'"s around the true universe sum.[6]

For any α, let $V(\alpha)$ be the largest value of H whose profit possibilities can be fully exploited. If H is greater than $V(\alpha)$, output must be less than the amount that would equate marginal cost and selling price. For any probability array, the α chosen will balance the extra fixed cost against the opportunity to utilize fully the profit possibilities of the larger values of H.

Enlarging the sample can be expected to reduce the dispersion of the probability distribution of "H"s. There will be less need for a large α, and α will be reduced. When α is reduced, cost is reduced. It is shown below that the profit expectation is increased.

According to equation (9), $X=(S-(A/\alpha))H/2B$. For $V(\alpha)$,

$$D\alpha = \left(S - \frac{A}{\alpha}\right)\frac{V(\alpha)}{2B} \tag{12}$$

or

$$V(\alpha) = \frac{2BD\alpha^2}{(S\alpha - A)}. \tag{13}$$

For any H less than $V(\alpha)$, the output limitation is inoperative. For such an H, the profit expectation per period is found by multiplying the profit equation by $p(H)$, the probability of H. Let P_1 be the result of integrating the profit expectations for all "H"s less than $V(\alpha)$.

$$P_1 = \frac{\left(S - \frac{A}{\alpha}\right)^2}{4B}\int_{-\infty}^{V(\alpha)} Hp(H)dH - C\alpha\int_{-\infty}^{V(\alpha)} p(H)dH. \tag{14}$$

For an $H \geqq V(\alpha)$, output must be $D\alpha$; maximizing profit requires a larger output, but no larger output is possible. With $x=D\alpha$, multiply each H by its probability, and integrate for all $H \geqq V(\alpha)$. Let P_2 be the result of the integration.

$$P_2 = D\alpha\left(S - \frac{A}{\alpha}\right)\int_{V(\alpha)}^{\infty} p(H)dH - B(D\alpha)^2\int_{V(\alpha)}^{\infty}\frac{p(H)dH}{H} - C\alpha\int_{V(\alpha)}^{\infty} p(H)dH. \tag{15}$$

The profit expectation for all "H"s is $P=P_1+P_2$ for each period.

[6] Croxton and Cowden, *Applied General Statistics*, p. 314.

$$P = \frac{\left(S - \frac{A}{\alpha}\right)^2}{4B}\left[H_i - \int_{V(\alpha)}^{\infty} Hp(H)dH\right] + D(S\alpha - A)\int_{V(\alpha)}^{\infty} p(H)dH - B(D\alpha)^2\int_{V(\alpha)}^{\infty} \frac{p(H)dH}{H} - C\alpha. \tag{16}$$

The sample mean, $\overline{H}'$, is an unbiased estimate of the universe mean, so

$$m\overline{H}' = H' \tag{17}$$

is an unbiased estimate of H_i. Thus,

$$P = \frac{\left(S - \frac{A}{\alpha}\right)^2}{4B}\left[H' - \int_{V(\alpha)}^{\infty} Hp(H)dH\right] + D(S\alpha - A)\int_{V(\alpha)}^{\infty} p(H)dH - B(D\alpha)^2\int_{V(\alpha)}^{\infty} \frac{p(H)dH}{H} - C\alpha. \tag{18}$$

Profit must be differentiated with respect to α, since the sampler is to select the most promising α. The parametric differentiation through $V(\alpha)$ vanishes, leaving

$$\frac{\partial P}{\partial \alpha} = 0 = \frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\left[H' - \int_{V(\alpha)}^{\infty} Hp(H)dH\right] + DS\int_{V(\alpha)}^{\infty} p(H)dH - 2D^2\alpha B\int_{V(\alpha)}^{\infty} \frac{p(H)dH}{H} - C. \tag{19}$$

Although the distribution of "H_i"s is not known, the probability distribution of means of samples will probably be nearly normal.[7] Calculations will be based on the assumption of normality.

[7] R. A. Fisher, *Statistical Methods for Research Workers*, 8th Ed., p. 112, " . . . Even if the original distribution were not exactly normal, that of the mean usually tends to normality, as the size of the sample is increased. . . ."

The standard error[8] of the sum will be

$$m\sigma_{\overline{H}'} = \frac{m\sigma_{H_i}}{\sqrt{n}} . \tag{20}$$

Since[9]

$$\sigma_{H_i} = \sigma_H \sqrt{\frac{n}{n-1}} \tag{21}$$

finally the standard error of the sum is

$$m\sigma_{\overline{H}'} = \frac{m\sigma_s}{\sqrt{n-1}} = \sigma_{H'}. \tag{22}$$

Let

$$z = \frac{H - H'}{\sigma_{H'}} \tag{23}$$

so that

$$H = H' + z\sigma_{H'}. \tag{24}$$

Let

$$t(\alpha) = \frac{V(\alpha) - H'}{\sigma_{H'}} . \tag{25}$$

$t(\alpha)$ sets a limit for the number of standard errors by which a possible H can be removed from H', without encountering the output limitation. (19) becomes

$$0 = \frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\left[H' - \int_{z=t}^{\infty}(H' + z\sigma_{H'})p(z)dz\right]$$

$$+ DS\int_{z=t}^{\infty}p(z)dz - 2D^2\alpha B\int_{z=t}^{\infty}\frac{p(z)dz}{H' + z\sigma_{H'}} - C$$

$$= \frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\left[H'\left(1 - \int_{z=t}^{\infty}p(z)dz\right) - \sigma_{H'}\int_{z=t}^{\infty}zp(z)dz\right]$$

[8] Croxton and Cowden, *Ibid.*, p. 307.
[9] Croxton and Cowden, *Ibid.*, p. 311.

$$+ DS\int_{z=t}^{\infty} p(z)dz - 2D^2\alpha B\int_{z=t}^{\infty}\frac{p(z)dz}{H' + z\sigma_{H'}} - C. \tag{26}$$

But $$\int_{z=t}^{\infty} zp(z)dz = \frac{1}{\sqrt{2\pi}}\int_{z=t}^{\infty} ze^{-z^2/2}\,dz = \frac{e^{-t^2/2}}{\sqrt{2\pi}} = p(t). \tag{27}$$

Therefore, (26) becomes

$$0 = \frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\left[H' - \sigma_{H'}p(t)\right] + \left[DS - \frac{A\left(S - \frac{A}{\alpha}\right)H'}{2B\alpha^2}\right]\int_{z=t}^{\infty} p(z)dz - 2D^2\alpha B\int_{z=t}^{\infty}\frac{p(z)dz}{H' + z\sigma_{H'}} - C. \tag{28}$$

Apparently (28) cannot be solved analytically. But it can be approximated. For a given α, $\int_{z=t}^{\infty} p(z)dz$ can be found directly from a table of normal curve values, and $\int_{z=t}^{\infty}\frac{p(z)dz}{H'+z\sigma_{H'}}$ can be approximated numercially by Simpson's Rule.[10]

After an α has been selected for trial, $V(\alpha)$ is calculated from equation (13). Next $t(\alpha)$ is found from equation (25). Thus (28) becomes

$$\frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\left[H' - \sigma_{H'}p(t)\right] + \left[DS - \frac{A\left(S - \frac{A}{\alpha}\right)}{2B\alpha^2}\right]\int_{z=[(2BD\alpha^2/S\alpha - A) - 10]/\sigma_{H'}}^{\infty} p(z)dz - 2D^2\alpha B\int_{z=[(2BD\alpha^2/S\alpha - A) - 10]/\sigma_{H'}}^{\infty}\frac{p(z)dz}{H' + z\sigma_{H'}}. \tag{29}$$

ILLUSTRATION

Let $A=1$
$B=S=5$
$C=D=4$

[10] Woods, *Advanced Calculus*, 2nd Ed. p. 139.

$m = 100$
$\overline{H}' = 0.1$
$\sigma_s = 0.03$
$n = 10$
No. of production periods $= 20$
Then (29) becomes

$$\frac{\left(5 - \frac{1}{\alpha}\right)}{10\alpha^2}[10 - p(t)] - 4 + \left[20 - \frac{\left(5 - \frac{1}{\alpha}\right)}{10\alpha^2}\right]\int_{z=(40\alpha^2/5\alpha-1)-10}^{\infty} p(z)dz - 160\alpha\int_{z=(40\alpha^2/5\alpha-1)-10}^{\infty}\frac{p(z)dz}{10+z} = 0. \tag{30}$$

Successive approximations will select α to any desired degree of accuracy. The optimum value of α must then be substituted into (18), and the profit expectation calculated. Then the profit expectation per period must be multiplied by the number of periods. In the present case $\alpha = 1.0398738$, the profit expectation per period is 3.9732113, and the net worth of the investment opportunity is 79.464226.

The addition of the $(n+1)^{\text{th}}$ item will cause a change in the profit expectation, and the anticipated rise in the profit expectation is the worth of adding the item. Since H' is an unbiased estimate of H_t, the expectation of change in the sample mean with the addition of another item is zero. Thus H' can be used in estimating the new profit expectation. But the sample sigma can be expected to decrease in the ratio $\sqrt{n/n+1}$. Thus when the computations are made in estimating the new profit, $m\sigma_s/\sqrt{n}$ should be used as $\sigma_{H'}$. In the present case, $\sigma_{H'} = 0.9486832$.

The α corresponding to the new $\sigma_{H'}$ is 1.0378347. The new profit expectation per period is thus 3.9762089, and the new investment worth is 0.059952. If adding the $(n+1)^{\text{th}}$ item does not cost more than 0.059952, the item ought to be added.

The procedure can be repeated for each additional item considered, until some item has a net worth less than its cost. Alternately, the computation could be made on the basis of adding items in groups of two or more.

The computational labor required is only moderate. The facts and estimates required are not drastically different from the data commonly used in progressive businesses.

AN INTERPRETATION OF THE QUANTITY INDEX

By Warren C. Waite
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The so-called Fisher "ideal" formula for price and quantity indexes has certain advantages in income studies. Among these are that multiplication of the price index by the quantity index computed on an analogous basis results in the value ratio of the two periods under consideration. This relationship is frequently utilized to derive the quantity index by dividing the value ratio by the price index. When this is done, it is not, however, always clear what the process involves other than to result in a number which if used to multiply the price index results in the value ratio.

The following example from an agricultural income study, by separating the quantity index into component parts, shows the effects of changes in the total physical quantities sold as well as changes in the proportions of the products sold. The data are the cash sales by Minnesota farmers of the nineteen principal agricultural products of the state for the period 1911 to 1941. Data at five-year intervals are given rather than the complete series. These data are particularly appropriate to illustrate the problem because of the great change in the character of Minnesota agriculture during the period. The quantity indexes in Table I have been obtained by dividing the value ratio by the price index computed on the basis of the "ideal" formula. It will be observed that the quantity index increases fairly rapidly until 1926, then levels off, and rises during the war.

TABLE I

INDEX OF VALUE OF SALES, PRICES AND QUANTITIES OF NINETEEN PRINCIPAL MINNESOTA AGRICULTURAL PRODUCTS

(1935–1939 = 100)

Year	Value ratio	Price index	Quantity index
1911	52.4	89.7	58.4
1916	75.0	113.0	66.3
1921	79.8	106.5	74.9
1926	135.2	137.1	98.6
1931	79.4	79.5	99.8
1936	106.8	110.0	97.2
1941	150.4	113.1	132.9

Additional computations relative to the quantity of sales are shown in Table II. The actual tonnage of sales results from the reduction of the

various products sold to tons and summing them. The value per ton is derived by dividing the total dollar value of all sales by the actual tonnage sold. In the given year this is $\sum p_1q_1/\sum w_1$ and in the base $\sum p_0q_0/\sum w_0$ where $\sum w_1$ represents the tonnage in the given year and $\sum w_0$ represents the tonnage in the base period. The value per ton is,

TABLE II

ACTUAL TONNAGE AND VALUE PER TON, DEFLATED VALUE PER TON AND RATIOS WITH 1935–1939 EQUAL TO 100 FOR SALES OF NINETEEN PRINCIPAL MINNESOTA AGRICULTURAL PRODUCTS

Year	Actual tonnage of sales (thousands)	Value per ton	Deflated value per ton	Ratio of tonnage 1935-39 = 100	Ratio of deflated value per ton 1935-39 = 100	Product of ratios
1911	4040	$40.37	$44.99	87.9	66.0	58.4
1916	3775	61.76	54.66	82.1	80.8	66.3
1921	4424	56.08	52.66	96.2	77.8	74.9
1926	4555	92.33	67.36	99.1	99.5	98.6
1931	3752	65.82	82.79	81.6	122.3	99.8
1936	4240	78.32	71.33	92.2	105.4	97.2
1941	6073	77.03	68.08	132.1	100.6	132.9

of course, greatly influenced by fluctuations in the level of prices. The values per ton have, in consequence, been adjusted to a uniform level of prices by dividing the actual values per ton for the various years by the index of prices for that year given in Table I. The deflated value per ton in the given year thus becomes:

$$\frac{\frac{\sum p_1q_1}{\sum w_1}}{\sqrt{\frac{\sum p_1q_0}{\sum p_0q_0} \times \frac{\sum p_1q_1}{\sum p_0q_1}}}$$

and for the base period:

$$\frac{\frac{\sum p_0q_0}{\sum w_0}}{\sqrt{\frac{\sum p_1q_0}{\sum p_0q_0} \times \frac{\sum p_1q_1}{\sum p_0q_1}}}$$

but since the index of prices is unity in the base period this may be reduced to $\sum p_0q_0/\sum w_0$. Changes in these deflated values per ton arise

from changes in the composition of the products comprising the ton of sales by the farmer. The upward trend in these values is occasioned by the shift of farmers from products with a relatively low value per ton to products relatively higher in value. In general, it represents more extensive processing on the farm. Instead of selling crops, the farmers of the state have increasingly grown crops to feed livestock with a product resulting which has a higher value per ton. This may be seen by examining the composition of the ratios of deflated ton values in the particular years to the base deflated ton values. The ratio of deflated ton values is:

$$\frac{\frac{\sum p_1 q_1}{\sum w_1}}{\frac{\sqrt{\frac{\sum p_1 q_0}{\sum p_0 q_0} \times \frac{\sum p_1 q_1}{\sum p_0 q_1}}}{\frac{\sum p_0 q_0}{\sum w_0}}}$$

which may be written as:

$$\frac{\frac{\sum w_0}{\sum p_0 q_0} \times \frac{\sum p_1 q_1}{\sum w_1}}{\sqrt{\frac{\sum p_1 q_0}{\sum p_0 q_0} \times \frac{\sum p_1 q_1}{\sum p_0 q_1}}}.$$

Examining this formula and assuming that the individual q_1 and q_0 are equal, it will be apparent that changes in p_1 relative to p_0 do not change the ratio since $\sum w_1$ would equal $\sum w_0$. If, however, the individual p_1 and p_0 are assumed to be equal, changes in q_1 relative to q_0 will change the ratio assuming the $\sum w_1$ remains equal to $\sum w_0$. The index of prices remains unchanged but the numerator of the fraction changes, rising if q_1 is increased where p_1 is above average and decreasing if q_1 is associated with a lower than average p_1.

In the latter portion of Table II, the actual tonnage and deflated value per ton are expressed as ratios with the average of 1935–39 as a base. The product of these ratios is given in the last column of the table and it will be noted that this product corresponds exactly with the quantity indexes of Table I. This must necessarily be true since when the formula above is multiplied by $\sum w_1 / \sum w_0$ it reduces to:

$$\frac{\frac{\sum p_1 q_1}{\sum p_0 q_0}}{\sqrt{\frac{\sum p_1 q_0}{\sum p_0 q_0} \times \frac{\sum p_1 q_1}{\sum p_0 q_1}}}$$

which in turn reduces to the Fisher "ideal" quantity index.

The tonnage ratios of our data show comparatively little change throughout the period, except for the increase in 1941. The deflated value per ton, however, increases considerably between 1911 and 1926. The rise in the quantity index for Minnesota cash sales between 1911 and 1926 is, therefore, due to a shift in the kinds of products sold rather than to any actual increase in total tonnage of sales. Between 1926 and 1936, the quantity index remains about the same, an increase in deflated value per ton about offsetting a decline in the total tonnage of products marketed. The increase in 1941 is due almost entirely to an increased total tonnage with little change in the composition of sales.

The quantity index constructed on the basis of the "ideal" formula thus takes into account both changes in physical quantities and the changing proportion of commodities when the relative values of the commodities are in terms of values per unit of weight. Thus the index will rise both when the total weight of products marketed increases with the composition of sales unchanged, and when the total weight of products marketed remains unchanged, or perhaps even declines, but the proportion of products having a higher value in terms of their weight increases.

SOME METHODS FOR THE EVALUATION OF A SUM

By Leo A. Aroian
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In many problems of economics, statistics, insurance, and accounting, it is necessary to find the sum of a large number of variates. This problem, which occurs repeatedly and often entails the loss of valuable time, was first called to my attention by the Metropolitan Life Insurance Company. That organization had used some of the methods without a complete investigation of the basic theory supplied in this article. The main subject of the paper is to show how this problem may be solved by means of existing statistical theory.

The fundamental solution.—Given T variates $x_1, x_2, \cdots, x_T$, we wish to determine $A=\sum_{i=1}^{T}x_i=T\overline{X}_p$, $\overline{X}_p=\sum_{i=1}^{T}x_i/T$. We take a sample of N items by a random process from the T variates and compute the mean of the sample, $\overline{X}_s=\sum_{i=1}^{N}x_i/N$. We estimate the mean of the population by the value of $\overline{X}_s$ and obtain for our estimate of A, $\bar{A}=T\overline{X}_s$. If this process were repeated for the ${}_TC_N$ samples possible, we would obtain a distribution of $\bar{A}$. This distribution in general approaches normality as N increases [1]. Naturally when $N=T$, $\bar{A}=A$. It is assumed that the variates forming the sample are replaced after each drawing of N items. It is well known that $\sigma_{\overline{X}_s}=\dfrac{\sigma_p}{\sqrt{N}}\sqrt{\dfrac{T-N}{T-1}}$, where $\sigma_{\overline{X}_s}$=standard deviation of the sample means, σ_p=standard deviation of the population [2]. We define $\mathsf{E}=\bar{A}-A$ and t by the equation $\int_{-t}^{t}y_t dt=1-\alpha$, where y_t is the normal probability function and α is the particular level of significance corresponding to t. Obviously, the expected value of E is zero, and $\sigma_{\mathsf{E}}=T\sigma_{\overline{X}_s}$. We are particularly interested in finding N for a predetermined E. Hence $t=\mathsf{E}/\sigma_{\mathsf{E}}$, or approximately

$$\mathsf{E}=tT\sigma_p\sqrt{\frac{1}{N}-\frac{1}{T}} \tag{1}$$

after we replace $T-1$ in the denominator of $\sigma_{\overline{X}_s}$ by T. Solving (1) for N we find

$$N=1\div\left\{\left(\frac{\mathsf{E}}{tT\sigma_p}\right)^2+\frac{1}{T}\right\}=1\div\left\{\frac{1}{T}\left(\frac{\mathsf{E}^2}{t^2\sigma_p{}^2T}+1\right)\right\}. \tag{2}$$

From (1) it is evident that E at the α level of significance increases as T and σ_p increase, and decreases as N increases.

In a specific problem E is determined in advance at some arbitrarily chosen level of significance by which t is fixed, T is generally known or found by counting, by measurement, or by weighing. (It is assumed that the variates are entered on cards or listed in columns on a sheet of paper.) The standard deviation for rough exploratory work may be estimated as the range divided by 4, 5, 6, or 7 depending on the nature of the distribution. For a more accurate determination of N we estimate σ_p by use of a small sample. After T, E, σ_p are estimated or known we solve for N by (2). Ordinarily N will be very much less than T. The average confidence belt will be 2E and only in 5 per cent of the cases in the long run of statistical experience, at the 5 per cent level of significance will we construct confidence limits in which A will not lie. The confidence limits will be

$$\tilde{A} \pm tT\sigma_s\sqrt{\frac{1}{N} - \frac{1}{T}} \tag{3}$$

where σ_s is the standard deviation of the sample of N items used as an estimate of σ_p. While σ_p^2 may be estimated more accurately by $\frac{N}{N-1}\frac{T-1}{T}\sigma_s^2$, since N and T are both large, this refinement is of little value here.

Limitations and difficulties.—Some limitations and possible difficulties should be stressed. Care should be taken concerning the approach to normality of E. Estimates may be made of

$$\alpha_{3:\,\mathsf{E}} = \alpha_{3:\,\bar{X}_s} = \frac{T-2N}{T-2}\sqrt{\frac{1}{N}\left(\frac{T-1}{T-N}\right)}\alpha_{3:\,p},$$

or approximately $\alpha_{3:\,\mathsf{E}} \sim \alpha_{3:\,p}/\sqrt{N}$, where $\alpha_{3:\,p}$ is the usual measure of skewness of the population. It is desirable that $|\alpha_{3:\,\mathsf{E}}| < .1$. An alternative, more troublesome, would be to use the Type III distribution for determination of t [3]. Usually we are generous in the value of N and equation (2) is a guide.

Stratified sampling.—In place of random sampling over the whole population, sometimes it is possible to arrange the variates in order of increasing magnitude or in groups more or less homogeneous. In such instances stratified sampling is decidedly more economical in that a smaller value of N will be needed for the same value of E [4]. We define

$\overline{X}_i$ = mean of the i^{th} stratum, $A = \sum_{i=1}^{r} T_i \overline{X}_i$, r strata in all, where the i^{th} stratum has T_i variates, $T = \sum_{i=1}^{r} T_i$. Let N be the number of individuals in the sample, and let N_i be chosen from each stratum, $N = \sum_{i=1}^{r} N_i$. Let σ_i^2 be the standard deviation of the i^{th} stratum. Let $\tilde{A}$ be our estimate of A, $\tilde{A} = \sum_{i=1}^{r} T_i \overline{X}_{s_i}$, where $\overline{X}_{s_i}$ is the mean of a sample of N_i individuals from the i^{th} stratum. Now it is known that $\tilde{A}$ is normally distributed as N becomes large [4] with variance

$$\sigma_{\tilde{A}}^2 = \sum_{i=1}^{r} T_i^2 \frac{\sigma_i^2}{N_i} \left(\frac{T_i - N_i}{T_i - 1} \right).$$

Our estimate of σ_i^2 will be $\tilde{\sigma}_i^2 = \dfrac{N_i}{N_i - 1} \dfrac{T_i - 1}{T_i} \sigma_{s_i}^2$, where $\sigma_{s_i}^2$ is the variance of a sample from the i^{th} stratum. Since N_i and T_i in many cases are large, we often use the approximation $\tilde{\sigma}_i^2 = \sigma_{s_i}^2$. As in the previous case, we have $\mathsf{E} = \tilde{A} - A$, $\sigma_{\mathsf{E}} = \sigma_{\tilde{A}}$, $t = \mathsf{E}/\sigma_{\mathsf{E}}$, or

$$\frac{\mathsf{E}^2}{t^2} = \sum_{i=1}^{r} T_i^2 \frac{\sigma_i^2}{N_i} \left\{ \frac{T_i - N_i}{T_i - 1} \right\} \tag{4}$$

and the only unknowns are the N_i. These values of N_i, the number of individuals in each stratum, may generally be found by trial and error in order that $N = \sum_{i=1}^{r} N_i$ be a minimum, or by calculus, or by finite differences since N_i is a discrete and not a continuous variate. In practice, trial and error seems most expeditious, particularly where an approximation to N is suitable. A measure of skewness, $\alpha_{3:\mathsf{E}}$, may be found in this instance also, but since N is generally large it is not given here. The confidence limits naturally are

$$\tilde{A} \pm t\sigma_{\tilde{A}}. \tag{5}$$

Some examples.—As an example we select the finite population consisting of the squares of the first thousand integers 1, 4, 9, · · ·, 1,000,000. Since the items range from one to one million, this example is particularly difficult and is one which would seldom occur in business. The sum of these thousand items is 333,833,500 and T is naturally 1000. The reader may follow the subsequent explanation by consulting a table of squares readily available in many statistical texts. At the 5 per cent level of significance $t = 1.96$, but $t = 2$ is sufficiently accurate for our purposes. Dividing the range, approximately 1,000,000, by 5 we find as our estimate $\sigma_p = 200{,}000$. The choice for E is 2×10^7. If the values for t, σ_p, T and E are substituted into (2), we find that N is 286.

By random sampling methods (Tippett's *Table of Random Sampling Numbers* or any of the other similar tables may be used) 287 items were chosen. We found $\overline{X}_s$ to be 361,900 and $\bar{A} = T\overline{X}_s = 361.9$ millions. The confidence limits at the 5 per cent level of significance from (3) were 342–382 million. We found that a better estimate of σ_p from the sample of 287 was 298,000 and the correct confidence limits of 332–392 million which includes the population value, 333,833,500.

The advantages of stratified sampling, when feasible depending upon arrangement of the material, will be immediately evident in this case. With only 100 items in all, more accurate results are obtained than with the 287 items of the previous case. We divide the variates into 10 strata 1–100,000, 100,001–200,000, etc. We assume $\sigma_i = 30{,}000$, $i = 1, 2, \cdots, 10$. This estimate is approximately the range in a stratum divided by 3, and is quite close. Obviously $T_1 = 316$, $T_2 = 131$, $T_3 = 100$, $T_4 = 85$, $T_5 = 75$, $T_6 = 67$, $T_7 = 62$, $T_8 = 58$, $T_9 = 54$, $T_{10} = 52$; E we take as 6.24×10^6 and for the 5 per cent level of significance $t = 2$. These values of σ_i, T_i, $i = 1, 2, \cdots, 10$, t and E we substitute in (4) and by trial we find $N_1 = 50$, $N_2 = 7$, $N_3 = 7$, $N_4 = 6$, $N_5 = N_6 = N_7 = N_8 = N_9 = N_{10} = 5$, $N = \sum N_i = 100$. After we had chosen a random sample in each stratum, the values of the sample means turned out to be $\overline{X}_{s_1} = 30{,}406$, $\overline{X}_{s_2} = 144{,}940$, $\overline{X}_{s_3} = 250{,}904$, $\overline{X}_{s_4} = 349{,}597$, $\overline{X}_{s_5} = 449{,}350$, $\overline{X}_{s_6} = 542{,}034$, $\overline{X}_{s_7} = 632{,}231$, $\overline{X}_{s_8} = 747{,}490$, $\overline{X}_{s_9} = 844{,}849$, $\overline{X}_{s_{10}} = 941{,}100$ and $\bar{A} = \sum T_i \overline{X}_{s_i} = 330.5$ million with confidence limits by (5) of 324–337 million. More accurate results could be obtained by increasing the number of strata and the size of the sample. It did not seem worth while to calculate the σ_i^2 more accurately than the estimate used. In some applications of stratified sampling we have used less than 1/10 of 1 per cent of the total variates, a real saving in time for the purpose at hand.

Some comments.—Generally in practical work the time spent in using Tippett's tables will not be justified. Instead, a systematic sample is chosen by taking every 10th or every 20th item if the sample is one of 10 per cent or 5 per cent respectively. There will be no dangers unless a cyclical influence is present. A recent paper by the Madows [5] may be consulted concerning the advantages of systematic sampling.

Statistical methods of the type considered in this article promise to be of considerable usefulness in those fields where extended calculations must be made and where a limited accuracy is acceptable. Grouping methods, punched card systems, and the use of a limited number of significant figures do not displace the methods here demonstrated. In fact, sampling may be combined quite efficiently with these other three devices.

I wish to express my appreciation to Professor Marguerite Darkow of Hunter College for reading the manuscript and for making helpful suggestions for its improvement.

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INDUSTRIAL CLASSES IN THE UNITED STATES IN 1940

By Tillman M. Sogge

In an earlier article entitled "Industrial Classes in the United States in 1930," published in this Journal in June 1933, the writer classified the gainful workers in the United States for 1870 to 1930 into industrial classes.[1] This paper brings this classification up to date by adding the data for 1940.

The fact that a new occupational classification was used in the Census of 1940 made the task of regrouping the data for 1940 into this classification somewhat more complicated, but the work was facilitated by the use of the Census report "Comparative Occupation Statistics for the United States, 1870 to 1940" by Dr. Alba M. Edwards.

It was possible to assign all the occupations in the 1940 Census to the classifications used and described in earlier articles in this series covering the period from 1870 to 1930 except the occupational group, "blacksmiths, forgemen and hammermen." This group was reported by the Census in two categories in 1930 (a) "blacksmiths" included in this classification as "unclassified" and (b) "forgemen and hammermen" included as "industrial wage earners." In these tabulations the 87,166 "blacksmiths, forgemen and hammermen" reported in 1940 have been allocated to the two groups "unclassified" and "industrial wage earners" on the basis of the ratios determined from the 1930 distribution when there were 124,373 "blacksmiths" and 23,096 "forgemen and hammermen." From these ratios, of the 87,166 "blacksmiths, forgemen and hammermen" in 1940, 84 per cent or 73,219 have been allocated to the "unclassified" group and 16 per cent or 13,947 are included as "industrial wage earners."

Even though the classification remains basically the same the change from the concept of "gainful worker" used in earlier Census periods to that of "labor force," used in 1940 should be kept in mind in making comparisons. The gainful worker data include all persons 10 years old and over reported as having a gainful occupation, regardless of their activity at the time of the Census. The statistics for 1940, however, include only those persons 14 years old and over who were in the experienced labor force during the week of March 24 to 30, 1940. The experi-

[1] These data for the years 1870 through 1920 were first presented by Professor Alvin H. Hansen in the two following articles which appeared in this Journal. (1) "Industrial Class Alignments in the United States," published in December 1920, and (2) "Industrial Classes in the United States in 1920," published in December 1922.

TABLE I

INDUSTRIAL CLASSES

	1870	1880	1890	1900	1910	1920	1930	1940*
Farm laborers	2,885,996	3,323,876	3,004,061	4,410,877	6,143,998	4,178,637	4,392,764	3,505,275
Farmers	3,000,229	4,282,074	5,370,181	5,770,738	6,229,161	6,463,708	6,079,234	5,328,049
Proprietors and officials	581,378	807,049	1,347,329	1,811,715	2,879,023	3,168,418	4,270,856	4,197,207
Professional	414,708	666,338	1,114,507	1,565,686	2,074,792	2,760,190	3,845,559	4,454,381
Lower salaried	309,413	529,473	965,852	1,329,928	2,393,620	3,985,306	7,116,814	8,071,201
Servants	975,734	1,075,655	1,454,791	1,453,677	1,572,225	1,270,946	1,999,133	2,840,021
Industrial wage earners	3,328,351	5,286,829	7,360,442	10,263,569	14,556,979	17,648,072	18,512,640	19,957,220
Unclassified	1,010,114	1,420,795	2,118,498	2,467,043	2,317,538	2,138,971	2,612,920	2,383,930
Total	12,505,923	17,392,099	22,735,661	29,073,233	38,167,336	41,614,248	48,829,920	50,737,284

TABLE II

INDUSTRIAL CLASSES (per cent)

	1870	1880	1890	1900	1910	1920	1930	1940*
Farm laborers	23.1	19.1	13.2	15.2	16.1	10.0	9.0	6.9
Farmers	24.0	24.6	23.6	19.8	16.3	15.5	12.4	10.5
Proprietors and officials	4.6	4.6	5.9	6.2	7.5	7.6	8.7	8.3
Professional	3.3	3.8	4.9	5.4	5.4	6.6	7.9	8.8
Lower salaried	2.5	3.0	4.3	4.6	6.3	9.6	14.6	15.9
Servants	7.8	6.2	6.4	5.0	4.1	3.1	4.1	5.6
Industrial wage earners	26.6	30.4	32.4	35.3	38.2	42.4	37.9	39.3
Unclassified	8.1	8.2	9.3	8.5	6.0	5.1	5.4	4.7

* These figures do not include 1,282,739 experienced persons in the labor force for whom occupations were not reported.

enced labor force consisted of (a) employed persons (except those on public emergency work), (b) persons on public emergency work, and (c) experienced workers seeking work, that is, persons without work of any sort who were actively seeking work during the Census week, and who had previously worked full time for one month or more. Certain classes of persons, such as retired workers, some inmates of institutions, recently incapacitated workers, and seasonal workers neither working nor seeking work at the time of the Census, were frequently included among gainful workers in 1930 and earlier years but in general such persons were not in the 1940 labor force. On the other hand, the 1940 labor force includes certain persons who would not have been counted as gainful workers in earlier Censuses.

Tables I and II indicate the number and percentage of gainful workers falling in each of the industrial classes for each ten year period from 1870 to 1930 and of the experienced labor force in 1940.

As the 1940 data in Tables I and II relate to persons 14 years of age and over whereas the 1930 figures include gainful workers 10 years of age and over, a special computation was made to determine the effect of this change. This computation provided a distribution of the 1930 gainful workers 14 years and over. This indicated that of the 235,328 gainful workers in 1930 who were less than fourteen years of age 205,563 were farm laborers, 51 were proprietors and officials, 974 were professional, 1,295 were lower salaried, 5,972 were servants, 10,112 were industrial wage earners, and 11,361 were included in the unclassified group. These relatively small numbers had only a minor influence upon the percentage distribution in Table II. A new percentage distribution based upon gainful workers 14 years and over led to the following changes in the percentages for 1930, $-.4$ for farm laborers, $+.1$ for farmers, $+.1$ for proprietors and officials, $+.2$ for industrial wage earners. All other percentages remained unchanged.

NOTES AND DISCUSSIONS

THE SOCIAL INSURANCE MOVEMENT

I

Under this title there appeared in the September 1943 issue of this JOURNAL an interesting article by R. Clyde White, giving a short but very good summary of the development of social insurance legislation. There is little to criticize except to call attention to some errors in the dates of Table I. This is even more important because in the publications of the International Labour Organization on Social Insurance (Series M) wrong dates have sometimes been given.

One of the first compulsory social insurance laws of the world, though very different from those of today, was that promulgated in 1854 for the miners of Austria covering sickness, invalidity, old age and survivors. Under this law the proprietors of mines were obliged to establish an insurance office for their subordinates or to join an already existing office. That law was replaced by a new one in 1889 which brought important improvements. In Germany in 1883 a law was introduced not for social reform as in the case of Austria but for mere reasons of political authority, which established sickness insurance not for a single professional group alone but still for a limited circle. This was followed in 1884 by a compulsory accident insurance law, the first draft of which was presented to the Reichstag in 1881. A law which appeared in 1878 on "socialist endeavors, dangerous to the common weal" created a kind of exceptional law against Socialists. This law was directed against quite a class of the population.

According to today's thought, social insurance ought to improve the condition of the poor classes of the population and to bring about a rational medical treatment. It provides for the family of the insured, that is his wife and children, and hence should influence favorably the coming generation and make children healthy and more capable of resisting illness. Social insurance legislation also is intended to improve family living, because the insured wins security in case of loss of income by sickness, etc. No one today calls social insurance "socialistic legislation." All states have an interest in the introduction of new or improvement of existing laws, though in imperialistic states among other aims there is that of the improvement of military potential. Nothing now remains of the erroneous ideas of Bismarck, that this type of legislation is merely socialistic. Indeed, many of the new social insurance laws no longer refer to workers or employees but to independent professions (artisans, representatives of free professions, etc.).

The draft of the Austrian bill referring to workers' compulsory accident insurance of the year 1881 became law at the end of 1887 after various alterations, and was published in No. 1 of the Law Advertiser of the Reich (Reichsgesetzblatt) of the year 1888. The sickness insurance law which had been considered by Parliament as early as 1885 was dated early in 1888 and

enced labor force consisted of (a) employed persons (except those on public emergency work), (b) persons on public emergency work, and (c) experienced workers seeking work, that is, persons without work of any sort who were actively seeking work during the Census week, and who had previously worked full time for one month or more. Certain classes of persons, such as retired workers, some inmates of institutions, recently incapacitated workers, and seasonal workers neither working nor seeking work at the time of the Census, were frequently included among gainful workers in 1930 and earlier years but in general such persons were not in the 1940 labor force. On the other hand, the 1940 labor force includes certain persons who would not have been counted as gainful workers in earlier Censuses.

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was published in the Reichsgesetzblatt, No. 33, ex 1888. The first law instituting compulsory insurance for employees (it also stems from Austria and not from Germany as has often been erroneously stated) was adopted at the end of 1906 and covered old age and survivors but not invalidity. Only five years later a similar law was adopted in Germany (1911). The first sickness insurance law in Hungary was published in 1891 and in Serbia in 1910. After the breakdown of the monarchy in 1918 the validity of the earlier laws has been maintained in the successor states as long as these will have made an own arrangement for their whole territory (Austria, Czechoslovakia, Italy, Poland, Roumania and Yugoslavia), so that in some of these countries different laws have been valuable so far.

As a supplementary remark it may be mentioned that social insurance legislation had already begun in 1890 in Iceland. This was not mentioned in Dr. White's table.

As to Venezuela the following may be stated: The bill of 1939 that purported to be able to cover sickness, invalidity, accident, old age and maternity at a premium of only 8 per cent was not accepted by Parliament, and the law of mid-1940 covers only accident, sickness and maternity. In article II there is stated expressly that old age, invalidity, survivors and unemployment will only be covered later by special laws. The statements mentioned should be changed correspondingly in Dr. White's first table.

ERIC MÍCHALUP

Caracas, Venezuela

II

Dr. Míchalup has raised several questions of fact concerning my article in the September 1943 number of this JOURNAL. I should like to comment on some of these.

It is quite correct to say that social insurance did not originate with Prince Bismarck and with the enactment of the German sickness insurance law of 1883. The use of the insurance principle in a mutual aid group was very common among the medieval craft guilds, but this was not government insurance nor general coverage in a geographical area or political subdivision. It was voluntary mutual aid. European miners have collected funds among themselves, sometimes supplemented by employers or some governmental unit, to pay the costs of sickness, accident or old age for hundreds of years. This was not social insurance in the sense in which I used the phrase nor in the sense in which most writers on social insurance use the term, although historically this kind of mutual aid may be regarded as an antecedent of the type of national legislation represented by the German sickness insurance law of 1883. There is fairly general agreement among writers on social insurance that 1883 is the year in which modern social insurance had its beginning, and 1884 when the German accident insurance law was enacted is generally

accepted as the beginning of accident insurance (or workmen's compensation in English speaking countries).

Dr. Mĺchalup takes exception to the dates which I assigned to the national insurance laws of some of the countries which prior to 1918 were constituent parts of the German Empire and the Austro-Hungarian Empire. Among these countries are Hungary, Serbia, Czechoslovakia and Poland. Some social insurance measures were operative in these countries prior to 1918, but as sovereign states these countries did not exist for the most part until after World War I, and I was concerned with their legislation as sovereign states. Iceland did have social insurance services, but it was taken by this writer as a constituent part of Denmark.

I accept Dr. Mĺchalup's correction regarding the effective parts of the social insurance laws of Venezuela. The law of 1940, Part I, 2 says, "Special Acts shall be enacted to extend compulsory social insurance to the risks of old age, invalidity, death and unemployment." For some reason the "special acts" did not get adopted, and I believe they are still in deferment.

It should be recognized that, like most historical matters, there is often good ground for a difference of opinion about matters of detail as well as matters of interpretation in social insurance. Dr. Mĺchalup is entitled to his opinion about some of these things, concerning which I differ, but I believe we are agreed as to the general fact of the steady and rapid growth of social insurance legislation throughout the world.

R. CLYDE WHITE

Western Reserve University

A NOTE TO "ON THE SUMMATION OF PROGRESSIONS USEFUL IN TIME SERIES ANALYSIS"

The author regrets to say that the following errors have crept into the above article, this JOURNAL, September, 1944, on page 387.

In series (3) and (4) the general terms, which appear as $(2x-n+1)^r$ and $\left(\frac{2x-n+1}{2}\right)^r$, should have been $(2x-n-1)^r$ and $\left(\frac{2x-n-1}{2}\right)^r$. Also the last term in the expansion of series (4), which was given as $\left(\frac{n-1}{3}\right)^r$, should have been $\left(\frac{n-1}{2}\right)^r$.

JOSEPH A. PIERCE

Atlanta University

BOOK REVIEWS

GLENN E. MCLAUGHLIN, *Review Editor*

The Design of Experiments, by R. A. Fisher, Third Edition. London: Oliver and Boyd, Ltd. 1942. xi, 236 pp. 12/6.

The three editions of this book are virtually the same, the changes consisting of a small amount of additional material in successive editions. Comprehensive and informative reviews of the earlier editions by Hotelling describing the content of the book and giving an exposition of some of the ideas were published in this JOURNAL in December, 1935, pp. 771–772, and in September, 1937, pp. 580–582. The new material in the present edition consists of Sections 45.1 and 45.2 in the chapter on confounding, which deals with a method of subclassification of the observations in such a way that differences on important variables may be made on reasonably homogeneous groups, while less important differences will be incorporated in or "confounded" with the group differences and thus be indistinguishable.

The book contains a number of ideas of great importance to individuals engaged in experimental work in the field of science. The fundamental issues presented in the first two chapters should be reviewed in detail by every scientific worker. The mathematical concepts and methods used by the author in his approach to experimental material have all of the beauty that one so often finds in illustrations of the art of pure mathematics. Considered, however, as an expression of applied mathematics, they seem to the reviewer to place too much stress on refinements that lead to the greatest efficiency in the analysis when the conclusions that are to be drawn from it are very strongly influenced by assumptions and judgments on which the analysis is based.

One important assumption of this character Fisher calls attention to on page 179 when he states that the methodology of the preceding seven chapters is subject to the assumption: "In this kind of hypothesis all discrepancies classified as error, and not eliminated from our comparisons by equalization or regression, are due to variation, in the material examined, following the normal law of errors with a definite and constant, but unknown, variance." The effects of this assumption may be and very often are far greater than those resulting from the differences between the more exact methods developed by Fisher and the approximate and simple methods that are in fairly common practice.

The judgment issue involved in statistical tests is the one which Fisher brings out in his discussion on page 13 where he states "It is open to the experimenter to be more or less exacting in respect of the smallness of the probability he would require before he would be willing to admit that his observations have demonstrated a positive result." When, as scientists, we are faced with the fact that the 5 per cent level of significance is nothing but

a "convenient convention," methods which classify our results with a high degree of accuracy relative to this conventional limit seem over-elaborate.

A good illustration of this issue is the example which Fisher discusses on pages 137–149, where he considers the result of an experiment carried out at Rothamsted in 1927. The mathematics of this analysis is beautiful but when one looks at the scientific conclusions as summarized in Section 53 one realizes that they do not differ in any degree from those that would have been reached by the conventional approximations to this exact analysis. In addition to that the analysis seems to this reviewer to completely omit one of the important scientific issues involved and that is that experiments of this type certainly fall into the realm of dosage reactions and although Fisher has used quantities (0), (1), and (2), the analysis pays no attention to where these quantities fall on a dosage scale. Table 23 on page 147 has a very strong suggestion that quantity (2) which is the level at which he draws his final conclusion is at entirely different relative positions on the dosage curve for the chemicals under consideration.

One could wish that the author had devoted more attention to the methods by which the scientist may check the effects of some of the necessary assumptions and to the ways in which we may justify "confounding," not by the internal evidence of the experiment at hand, but by experiments designed for this purpose. Both of these are of great importance in the design of experiments and fall very definitely within the field of responsibility of the mathematical statistician.

LOWELL J. REED

The Johns Hopkins University

Statistical Tables for Biological, Agricultural and Medical Research, by R. A. Fisher and F. Yates, Second Edition. London: Oliver and Boyd, Ltd. 1943. viii, 98 pp. 13/6.

The first edition of these tables, published in 1938, was reviewed in this JOURNAL by Snedecor, March, 1939, pp. 206–207. This review summarized the coverage of the tables, pointed out some of the unusual features, and predicted that they would prove a valuable aid to the practicing statistician. The soundness of this prediction is indicated by the appearance of the second edition five years later.

The second edition includes four new tables numbered V-1, V-2, VIII-1, and VIII-2, the numbering of the tables contained in the previous edition being unaltered. Table XVII, which gives combinatorial solutions, has been extended. The errata discovered in the first edition have been corrected and a partial list of these is given, p. viii, for the convenience of users of this earlier edition.

Tables V-1 and V-2 pertain to Behrens' tests of significance between two means, for the case where the means have sampling distributions with different values of the variance. Table V-1 deals with the distribution of differences resulting from two Student distributions with n_1 and n_2 degrees of free-

dom, Table V-2 with the distribution resulting from a normal component of known variance and a Student distribution.

Table VIII-1 deals with estimates of the probability of a single event, when the event has been observed to happen a out of N times.

Table VIII-2 aids in the determination of density of organisms from the dilution method if the dilution ratio is 2, 4, or 10.

All of these new tables contain a serious defect which detracts from their usefulness. This is a lack of clear and complete labelling of the argument and tabulated values. For example, Table V-1 is titled "Significance of Difference Between Two Means." The horizontal axis is tabulated in degrees at 15° intervals from 0° to 90° and is not labelled. The vertical axis is given in two columns, the first of which is headed "5 per cent points" followed by values of n_2. The second column is labelled n_1. The tabulated material which consists of 5 per cent points, is unlabelled. A paragraph in the introduction which pertains to this table fails to state explicitly what the table does contain. This criticism is not confined to the new tables, but applies to several of the original tables. Thus, the argument is not labelled in several of the original tables and in some of the others, including the first one of the normal distribution, the content of the table is not stated except indirectly in a footnote.

Once their content is ascertained the tables become a very useful part of our modern statistical equipment and the added material in this new edition will increase their range of application.

LOWELL J. REED

The Johns Hopkins University

Vital Statistics Rates in the United States: 1900–1940, by Forrest E. Linder and Robert D. Grove under the supervision of Halbert L. Dunn, M.D. Bureau of the Census, Washington: Superintendent of Documents. 1943. vii, 1051 pp. $1.75.

The vital statistician in particular and the student of social phenomena in general will have many occasions to turn to this very useful volume. During the 41 years covered by the book many changes in public health thinking have taken place and much progress has been made. The rates presented in this volume provide an excellent review of vital trends during this developmental period and furnish raw material necessary to any intelligent discussion of current and future medical, social, and economic problems.

The book contains 43 tables concerned with mortality rates, 9 with natality rates, and 17 with the population data on which the rates are based. Crude rates are presented first and then rates specific for age, sex, color, nativity, month of occurrence and cause of death. Tables showing the trend of the rates over the 41 year period come first followed by others showing, for 1940 only, the rates broken down for small areas. In addition there are two general summary tables for 1940 bringing together the material for each

of the three classes of data. Most of the rates are on a place of occurrence basis since only in recent years have data on a residence basis become available.

Use of the volume is considerably facilitated by the inclusion of tabular indices to the tables which enable the user to tell at a glance which tables contain the particular items he is interested in and whether or not they are cross-classified in the manner desired. The tabular index to the population tables is particularly valuable since it makes clear the population bases which may be used for computing the number of births or deaths contributing to any rate in the volume.

In addition to the tables there are five chapters of text covering 119 pages. Chapter I is introductory. Chapters II and III are concerned with the classification, tabulation. definition, and interpretation of vital statistics data. Chapter IV is a detailed discussion of adjusted rates. Although Chapters II, III, and IV are not requisite to the use of the tables, together with the list of references at the end of each chapter, they constitute an excellent introductory text for the student of vital statistics and will probably be used as such. Chapter V, Description and Explanation of Tables, is absolutely essential to the proper interpretation of data in the tables and should be carefully studied by users of the volume.

Original plans for the volume, which were curtailed because of the war, included the presentation of adjusted rates and other indices. It is hoped that eventually these plans will be realized. In the meantime, as the authors point out, "the most essential parts of such a volume are specific rates. . . . With these 'raw materials' the biostatistician can proceed with his own analyses and studies." Certainly the volume will be one of the most referred to in the field.

PAUL M. DENSEN

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School of Medicine

Statistical Analysis in Biology, by K. Mather. New York: Interscience Publishers, Inc. 1943. 247 pp. $4.50.

The author is head of the Genetics Department at the John Innes Institution, London, and has worked close to R. A. Fisher for a number of years. He presents, from the viewpoint of a biologist, most of the techniques developed in Fisher's *Statistical Methods for Research Workers* and some of those in Fisher's *Design of Experiments*. The exposition is lucid.

The distinction between the sample and the population and the concept of a test of significance are introduced at the beginning of the book, both with reference to the binomial distribution. The author then proceeds to a discussion of the normal and Poisson distributions and of the t, z, and χ^2 distributions. An introduction to the analysis of variance is followed by a chapter on the partition of degrees of freedom into single components. Chapter VII, on the planning of experiments, lays stress on factorial experi-

ments and describes randomized blocks, the Latin square, and the confounded $2 \times 2 \times 2$ factorial arrangements.

The ensuing section on regression theory is devoted to simple, multiple, and polynomial regressions and the analysis of covariance, followed by an example of the use of discriminant functions. Inter- and intra-class correlations are described rather briefly. The analysis of frequency data and more particularly of contingency tables is developed in considerable detail, presumably in view of its usefulness in tests of Mendelian inheritance. Included in this section are the rules for the sub-division of the "goodness of fit" χ^2 into single degreees of freedom—seldom given in text books. The book ends with an account of the method of maximum likelihood and of the elements of Fisher's theory of estimation.

Calculus is introduced only insofar as necessary in dealing with the method of maximum likelihood and the method of least squares. The rather free use of algebra in the later sections of the book is defended by the author, though it is doubtful whether some of the algebraic portions, e.g. the proof that one form of χ^2 gives results identical with another form, really contribute much to the reader's understanding of the subject.

The defects of the book arise mainly from the limited range of the author's reading in statistical literature, and his limited knowledge of statistical theory. Thus, as evidence that non-normality does not vitiate the analysis of variance tests, it is stated (p. 35) that "Actual data have been analysed by Eden and Yates and the insignificance of these errors has been fully demonstrated." In fact, the data analyzed by Eden and Yates are only slightly non-normal, as Neyman has pointed out, while the question of non-normality has been the subject of at least fifteen papers which are ignored by the author. Fisher's z-distribution is said (p. 45) to be "independent of the two true standard deviations" which is incorrect unless the true standard deviations are equal. The pooling of mean squares which are not significantly different is highly recommended (p. 78), without a realization that this practice renders the use of a subsequent z-test invalid, at least to some extent. The discussion (p. 79) of a group of barley experiments where year and place interactions enter is much over-simplified, though the complexities involved in a realistic analysis of these same data have been investigated by Yates and Cochran. The recommendation (p. 175) that χ^2 should never be used where any class frequency is less than 5 is over-cautious in view of recent work on this problem, and is not helpful, since the reader is not told what to do when a class frequency is less than 5. Actually the author breaks his own rule without comment (p. 191), where a χ^2 analysis is carried through with one frequency as low as 2. Similarly, the author's resolve to use Greek letters for population parameters and Latin letters for sample estimates is not well kept; thus p is used throughout for the parameter of a binomial distribution and λ is used for both population and sample weights in discriminant functions (p. 157). On p. 205 occurs the curious statement that Fisher's theory of estimation is independent of the theory of probability. In the glossary (p. 234), bias is described as "the average error of an estimate." The absence

of an adequate discussion of transformations is regrettable. Too many significant figures are carried in almost all computations.

W. G. COCHRAN

Princeton University

The Statistical Study of Literary Vocabulary, by G. Udny Yule. New York: The Macmillan Company. 1944. ix, 306 pp. $6.00.

This book is the outgrowth of a study started by the author to determine, by a consideration of vocabularies, whether *De Imitatione Christi* was written by Thomas à Kempis or by someone else. It soon became apparent to him that known statistical methods were inadequate to cope with the problem. Consequently he set about to devise general statistical procedures by means of which hypotheses regarding authorship and literary style could be objectively tested.

If the words employed in a certain writing are classified into the number used once, the number used twice, and so on, there is obtained a word-distribution, somewhat comparable to a distribution of accidents, which the Poisson exponential distribution has been used to describe. (Obviously this is also true for a sample from the writing or for words of a certain type, e.g. nouns or adjectives.) A word-distribution, however, differs from a distribution of accidents in that time is not specifically involved and that the distribution is decapitated, since the number of words that have not met with the "accident" of being used is unknown. Yule derives a characteristic for the decapitated distribution which is independent of sample size. By means of this characteristic he compares and contrasts word-distributions from different works of the same author and such distributions from works of different authors. He also discusses the alphabetical distribution of English vocabulary—his study of *De Imitatione Christi* is, of course, a study of the vocabulary of the Latin original—and makes an etymological analysis of the writings of certain English authors.

In his conclusion Yule modestly emphasizes the incompleteness of his work and stresses the need for a study of adjectives and verbs—his own study is concerned principally with nouns. He states that the methods developed are applicable to the study of languages-in-use and expresses the hope that they will not be used solely for the study of controversial matters. He suggests further problems both for the student of language and literature and for the theoretical statistician. Although I am not familiar with the methods used by the former, I am confident that he will do well to consult the book under review. It is written by a competent authority on general statistical methods and is sure to contain ideas which will prove helpful. The theoretical statistician will find it interesting and stimulating reading.

PAUL R. RIDER

Washington University, St. Louis

Readings in Business Cycle Theory, selected by a Committee of the American Economic Association. Philadelphia: The Blakiston Company. 1944. xvi, 494 pp. $3.75.

This collection of readings is the second of a series, the first having dealt with the social control of industry. Selections for this second volume were made by a special committee of the American Economic Association under the chairmanship of Professor Gottfried Haberler. Of the 21 readings reproduced, all but two are taken from economic and statistical journals, although several of the articles are available as reprints in other books.

The purpose of the volume as noted in the preface is to bring together under one cover "the most useful periodical literature" on business cycle theory. The two excerpts from books (one by Wesley C. Mitchell in *Business Cycles and Unemployment* and the other by Frederick A. Hayek in *Profits, Interest and Investment*) were chosen doubtless because the committee felt that no articles in periodical publications would fill so well the need for chapters on general description of business cycles and on price expectations, monetary disturbances and maladjustments. This digression suggests one of the characteristics of the volume, which is the fitting of short essays on specialized phases of business cycles so far as possible into an analytical framework of theory. Since the articles were not written to a predetermined outline, some duplications and contradictions are to be found, which, however, have been held to a minimum. Any disadvantages which arise from this source are more than counterbalanced by the advantages of a systematic presentation of the gems of business cycle literature. It scarcely seems possible that any single analyst or group of analysts writing anew to the same outline could produce a work of equal richness of thought.

Nevertheless, the collection of readings, in the reviewer's opinion, can hardly qualify as a general treatise on business cycle theory, Too much stress is placed on financial overlay and prices as factors in business cycles and too little on such aspects as psychological and physical factors which produce variable reactions in the course of time and which may be at the root of at least part of the financial and price variations. Can it be denied that the psychological and physical derangements of the present war period, for example, will exercise a substantial, if not a controlling, influence on business cycles yet to come?

The selection committee appears to have viewed the problem through the special glasses so typical of present-day business cycle theorists. This concentration of attention reminds one of the young farmer who at the outset of his career purchased a team of white horses of which he became exceedingly proud. Thereupon he observed that he grew keenly interested in horses—provided that they were white. Although the reviewer has no strong feeling against the "white horses" of business cycle theory, he does believe that the blacks, browns and sorrels should be given more attention.

The same limitation of scope does not apply to an excellent, 42-page, classified bibliography of business cycle articles supplied by Professor Harold

M. Somers. The classification in this bibliography parallels that in the body of the book, but contains in addition extensive references to psychological influences; technology; innovations; depreciation; inventories; wages, costs and prices in relation to output and employment; monopolistic factors; special fluctuations in agriculture and building; and the influence of wars and population growth.

WILBERT G. FRITZ

War Production Board

Economic Fluctuations in the United States, by Edwin Frickey. Cambridge: Harvard University Press. Harvard Economic Studies 173. 1942. xxi, 375 pp. $5.00.

Professor Frickey sets himself the task of describing the secular and cyclical movements of major composite series for the period 1866 to 1914. His work is important for two principal reasons. The decomposition of series into cyclical and secular movements is performed meticulously by methods which are as objective as possible. The pattern of cyclical movement is found to be strikingly similar for various processes of change and to be pervasive through the economy.

The conventional method of fitting and eliminating a trend does not face the question as to the proper method of decomposition. The length of the cycle of pig iron production, for instance, varies more than 10-fold depending on the trend fitted and period used. Frickey's study assumes as evident only the presence of seasonal and irregular fluctuations. Taking the 13 composite series on which data are available for the period, cyclical fluctuations are discovered which are found by several methods to be most uniform as relative fluctuations. Accordingly, period to period changes are investigated in terms of link relatives rather than first differences. To facilitate the comparison of the short-run fluctuations, long period drift is reduced by expressing each link relative series in deviations from its average link relative; each series is then divided by its dispersion measure; time adjustment is made to correct for lagging in 7 of the series. A link relative standard pattern is developed by averaging the 7 middle link relatives in the array. These computations are carried out for quarterly, annual, two, three, six, and nine year periods. The short-period fluctuation remains strikingly similar for the various series until six-year periods are employed.

The standard pattern derived from the 13 series is compared with carefully developed measures of total production, manufacturing production, agricultural crop production, transportation and communication, trade, manufacturing employment, and commodity prices. All of these cyclical patterns are found to be surprisingly similar to the standard pattern. This evidence, the reviewer believes, greatly strengthens the case for pervasiveness of the general business cycle in the period studied. The showing demonstrates the interdependence of cycles in different industries and processes.

The uniformity of the cyclical pattern is the key to Frickey's procedure in decomposing time series. The production index, chained from link relatives, is divided into 7 cyclical sub-periods measured from the base line, and decomposition is studied separately for each cyclical period. The cyclical movement in production in each of the cyclical periods is compared with 12 of the other series selected for the purpose. Two methods are employed in separating the time series elements. First, the logarithmic parabola is established as an appropriate trend for the production index partly by a study of logarithmic differences. The production index is used as a "denotative" series in decomposing other series—the cycle is eliminated by dividing by the form established by the cycle in production. Thereby, trend indications are established. Second, a method of gradual attenuation is employed. As a first approximation, the standard pattern is employed to isolate approximate trend indications separately by sub-periods. By use of the trend indications so developed the standard pattern is revised which in turn is again used to isolate trend indications, etc.

Finally, on the basis of the analysis so described, and the employment of a minimum amount of discretionary judgment, trends are fitted mathematically to a modified series derived from the most important data available for the period.

No sketchy review of Frickey's procedures can possibly portray the care with which alternative possibilities are examined, second demonstrations are developed independently on various questions raised, and controls are set up to check against bias. No student can fail to be impressed by the care with which the study was made.

Frickey's results do not replace conventional trend-cycle separation, at least for the present. His results cannot assuredly be given wider application, especially when individual industries are studied, and in any case extensive and tedious analysis would be required. The fact that his conclusions tend to verify those arrived at by the less objective conventional time-series decomposition would appear to give confidence in results obtained from these conventional methods when they are employed with care.

The conclusion that the series studied in the 50-year period demonstrates one pervasive cyclical pattern and smooth secular movements for composite series is of first importance. It weakens the case for a series of concurrent cycles in the United States. (It, however throws no light on very long cycles such as the "Kondratieff," because only 50 years are covered.) This conclusion would be immediately much more useful if Frickey had developed a studied comparison between the cyclical periods he established and the greater number often read into three of his sub-periods (as shown in parenthesis): 1866–78 (2), 1885–96 (4), 1896–1904 (2).

Minor conclusions Professor Frickey has developed are as important as the major ones reached in many books. The cyclical movement in the series studied shows a close approximation to a relative relationship to the secular trend. As a corollary logarithmic differences are effectively employed as a technique in studying trends. Secular trends for separate industries appear

to be more complicated than they are often assumed. In contrast, the secular trend of the production index is a simple logarithmic equation, simpler than the trends for most economic processes.

Frickey's book is a report on research and he has not deviated from careful reporting. Unfortunately the style is somewhat tiring. The book is recommended to all social students who draw conclusions on general economic change, and who does not? No direct applications are made to present day economic changes but those who appeal to history should understand Frickey's findings.

ELMER C. BRATT

Washington, D. C.

Postwar Monetary Plans and Other Essays, by John H. Williams. New York: Alfred A. Knopf. 1944. viii, 297 pp. $2.50.

Dean Williams renders a distinct service to students of monetary policy by reprinting here eleven of his papers on different phases of the subject originally published in various journals from 1929 to 1944. Part I contains the three most recent papers, dealing specifically with the Keynes and White plans and related problems. Part II deals with deficit spending and the relation of fiscal and monetary policy. Part III discusses international trade and the gold standard against the background of the depression years.

Within each group the papers are arranged chronologically to show the development of the author's thought. He examines the classical theories and the contemporary ones and in successive papers shows where they fail to satisfy his thinking and suggests modifications of theory and practice. He is never dogmatic, never sure that a certain theory is correct or a certain policy perfect; but he gets down to the fundamental factors that must be considered.

There is not space here to consider the stimulating papers in Parts II and III, for those in Part I on "Postwar Monetary Plans' are naturally of the greatest current interest. Dean Williams amplifies them with a 22-page introduction, written before the Bretton Woods Conference, but still pertinent. He discusses various details, such as the necessity of continuing exchange controls during the transition period for all and longer for the "younger agricultural countries"; the need for allowing for economic growth and the business cycle, neither of which figured in the classical theory of the gold standard; the problems raised by the dominant position of the United States in the world economy, with other countries likely to want more dollars than we want of their currencies; the probable desirability of considerable adjustments of exchange rates even after the transition period; and numerous other matters. On the more fundamental plane he feels it would have been better to tackle first the problems of relief, reconstruction, and war balances, "counting primarily upon exchange controls to keep currencies stable until these problems had been solved." And for the long run:

. . . I come back always to the conclusion that the problem of international monetary stability is primarily that of maintaining a state of proper economic health in the leading countries; and this is the only workable answer to the whole conflict between internal and external monetary stability, about which discussions of the gold standard for years revolved.

DICKSON H. LEAVENS

Cowles Commission for Research in Economics

Canada's Financial System in War, by Benjamin H. Higgins. New York: National Bureau of Economic Research. 1944. 82 pp. 50 cents.

The author, a professor of economics at McGill University and a member of the National Bureau's Research Staff, begins his study with a broad survey of the policies which enabled Canada to increase federal expenditures from one-tenth of gross national product in 1939 to one-half in 1943 with a minimum of inflation. He outlines the main wartime developments in the Dominion's tax system, describes concisely the direct controls over prices and production which have provided the essential complements of fiscal measures, and notes the character and extent of the industrial expansion which has made it possible for the war to be financed without curtailing civilian consumption except in highly durable consumer's goods. This section provides a useful summary of the basic elements of Canada's war economy.

The two succeeding sections extend the scope of the study so as to justify its title. Dealing mainly with the borrowing side of war finance, they describe the machinery through which government bonds were sold, show into whose hands they went, and review the effects of wartime operations and participation in war loan issues on the balance sheet items of the banks and the investment portfolios of life insurance companies. But they consider also such matters as the influence of the war on business profits, the working capital of corporations, and retail credit, and the investment problems the insurance companies will face after the war. The sections are accordingly not free from discursiveness, and the reader, left at points without a clear sense of direction, will find them on the whole less satisfactory than the first part of the study.

The remainder of the work shows how far Canada has progressed since the first World War, both in the understanding of the principles of war finance and in the ability and will to put them into practice. In contrasting financial policies and their effects in the two World Wars the author takes due account of the relative smallness of the war effort in the previous war and the correspondingly minor use made of direct controls over the allocation and prices of goods and services.

WILLIAM H. WYNNE

Office of Civilian Requirements
War Production Board

Steel in Action, by Charles M. Parker. Lancaster, Pennsylvania: The Jacques Cattell Press. 1943. vi, 221 pp. $2.50.

This book is designed to tell its readers what steel is, how it is made and what part it has played in serving America in peace and in war. Nearly half of the volume is devoted to a description of the physical processes of steel making. This part of the book is one of the best simple treatments of the subject this reviewer has ever read. The brief historical chapter is also well handled. In the latter part of the book which is concerned with the control of raw materials, wartime expansion, and markets, the author deviates occasionally from description in order to philosophize a bit on such subjects as the desirability of living in the United States and the reasons why the United States has become a great nation. These digressions tend to detract somewhat from the clarity of the presentation. One chapter describes the expansion of the industry during the present war and the adaptability of the industry's technicians to wartime problems. No comments are made, unfortunately, on the many issues raised by competing proposals for expansion.

Almost no treatment of the economics of the industry is included, except that which is incidental to a discussion of raw materials sources. The author attaches considerable importance to the relation of the location of iron ore reserves to peace negotiations. In his comparison of the steel industries of the world he overemphasizes United States industrial and metallurgical superiority. From a statistician's standpoint the book is not useful as a source of factual information, nor is it intended to be. The chapter on the steel industries of the world has, however, a good brief description of the sort of steel capacity controlled by the main producing countries in the world. For those not familiar with the industry this chapter, like the earlier chapters on production, has the advantage of giving as much information as the average reader needs.

In the latter part of the book, some of the recent advances in technology are reviewed in terms which should be understood by the casual reader, without using the ecstatic expressions so frequently found in popular books and articles. The author's views of the post-war markets—both domestic and foreign—seem rather optimistic. He touches only slightly on competing materials, such as aluminum, plastics, etc., stating that all will participate in the markets "but the workhorse will be steel."

Taken as a whole the book contains much useful information for a reader who is looking for general factual information. It is, however, too limited in scope to be of much value to a serious student of the economics of the industry. Because of its popular nature, it is too bad that it contains so few diagrams and pictures.

Marion Worthing

War Production Board

The Geography of World Air Transport, by J. Parker Van Zandt. Washington: The Brookings Institution. 1944. viii, 67 pp. $1.00.

This is the first of three projected volumes. The second will be on the relation of civil aviation to military power, the third on organization and operation of world air transport. The present volume is primarily devoted to clearing away various popular misconceptions as to the geography of international aviation. The book is easy reading and should contribute to public understanding.

Aviation specialists will find the book of value because of the skill with which the author has clarified his materials to bring the most important geographic relationships into sharp focus. This is achieved partly by concentrating attention on "the principal hemisphere," that half of the globe which includes 94 per cent of the world's people and 98 per cent of all industrial activity. Air routes of primary economic importance are further identified by an analysis of basic statistical material in terms of eight major world trade areas. The tabulations in Appendix B may prove convenient for use by statisticians interested in a variety of global matters. Appendix A is devoted to an ingenious device developed by the author to facilitate great circle computations on flat maps.

PAUL T. DAVID

Washington, D. C.

New Firms and Free Enterprise, by Alfred R. Oxenfeldt. Washington: American Council on Public Affairs. 1943. ii, 196 pp. $2.50.

In treating the life cycle of business enterprises the author departs from the usual analysis of business mortality and directs his study to the birth of new firms. The timeliness of such a treatment when everyone is thinking of new businesses in the postwar period is emphasized in a preliminary note.

New firms have economic significance in that they influence: (1) the allocation of resources, (2) the outlets for investment goods and investible funds, (3) the introduction of new products and new methods of production and sale, (4) the intensity of competition, (5) the waste of resources, and (6) the economic and social advancement of individuals. The effect of the establishment of new firms upon each of these phases of the economy is outlined with clarity and considerable precision.

By putting various data together, Dr. Oxenfeldt has developed some interesting statistics. For instance, between 1936 and 1940 on the average 160,000 businesses were completely new, and about 270,000 had elements of newness. The volume of new enterprises reached its peak in 1925. In the years immediately preceding the outbreak of the war new businesses were considerably fewer than in any year during the decade of the 1920's. The chances that an individual will establish a business during his lifetime, if no individual entered more than one business, is about one in five; however, on the average, entrepreneurs establish about three firms each, so it may be

estimated that one out of every 15 persons at some time becomes an entrepreneur.

Not the least interesting of the points discussed is the author's analysis of the unrealistic approach of economists who assume that most entrepreneurs have information as to the profit-making possibilities of various businesses, or that they use the information which is available rationally. In this, as in many other parts of the discussion, the author faces the difficult task of generalizing about things that are essentially different, such as entrance into the grocery business and entrance into the steel manufacturing business. In the latter case close study of opportunities is undoubtedly a requirement for beginning a new business, as a number of experienced capitalists have to be convinced of profit-making possibilities before risking their money; the small retailer, on the other hand, aided and abetted by those who will gain by his excursion into the unknown, is usually unable or unwilling to face the facts and simply takes a chance. In like manner, it can be pointed out, that, although the desire to avoid unemployment or to lift one's social status may motivate large numbers to enter the grocery business, these reasons probably have little influence on the enterpreneurs entering the steel business.

In view of his conclusions that (1) "most profitable opportunities . . . are eventually discovered," (how the opportunities which are not discovered can be counted is not explained), (2) new firms add to the cost of distribution and production when they duplicate facilities which are already adequate, (3) most new firms seem to be a source of waste, (4) new enterprises seem to impair rather than contribute to economic welfare, Dr. Oxenfeldt's recommendation that a specialized government organization be created to lend to new firms, seems hardly justified, even if "the establishment of a concern provides some individuals with an escape from unemployment and others an escape from the humiliation that sometimes attaches to employment in the business of another."

E. D. McGarry

University of Buffalo

The Labor Force in Wartime America, by Clarence D. Long. New York: National Bureau of Economic Research. 1944. 73 pp. 50 cents.

After examining the nature and extent of manpower mobilization in the United States, Great Britain, and Germany during World Wars I and II, Mr. Long concludes that "the possibilities of net additions to the normal labor force in wartime have been exaggerated." By "net additions," Mr. Long means expansion of the labor force through bringing in, as workers and soldiers, persons who would not be there in peacetime. This excludes increases in total labor input resulting from more intensive utilization of the existing labor force through lengthening hours of work or reducing unemployment.

Mr. Long believes that the additions to the American labor force during World War I were almost wholly "illusory." He develops this point, first by attempting to show that the estimates of the National Industrial Conference Board, which indicate that employment in 1918 exceeded the "normal" labor force by more than 3 million, were grossly in error, and second by advancing evidence to indicate that wartime additions of students and women to the labor force were negligible. The arguments are not convincing, however, because they are predicated upon assumptions which appear questionable in the absence of detailed supporting data (see below).

Even the acceptance of Long's belief that abnormal additions to the American labor force during World War I were virtually non-existent would not necessarily imply the acceptance of the general conclusion that the wartime expansibility of the labor force is limited. For the United States the last war was of relatively short duration and one which did not tax severely the manpower resources of the Nation. The same cannot be said of Britain and Germany, however, and Long also discusses the experience in these two countries. He points out that Germany suffered a net loss of 18–20 per cent in the civilian labor force and Great Britain a loss of 10–13 per cent. But the expansion in the armed forces according to Long amounted to approximately 33 per cent of the normal labor force in Germany and 25 per cent in Britain. Do these figures support the conclusion that wartime additions to the Labor force were largely "illusory"? Indeed, it would appear to this reviewer that they tend to support exactly the opposite conclusion. They indicate that the total labor force (civilian and military) in both Germany and Britain expanded in the order of 12–15 per cent over normal. This is approximately the same degree of expansion that has occurred in the United States during the current war. According to the Bureau of Labor Statistics the total labor force in the spring of 1944 exceeded normal peacetime expectations by approximately 6½ million or 12 per cent.

Long's conclusion that the "possibilities of net additions to the normal labor force in wartime have been exaggerated" would indicate that this increase of 6½ million in the labor force is smaller than was expected at the beginning of the war. Yet recollections of discussion on manpower problems during the early days of the war and reference to Congressional testimony taken at that time suggest that the possibilities for expansion in the labor force were underestimated rather than exaggerated. During 1942 a decision was reached setting the objective size of the armed forces at about 10 million. It was felt, however, that mobilization of men on this scale could not be achieved without either a more drastic curtailment of employment in the so-called "nonwar" industries or a more rigorous administrative control of the labor market than has in fact proved necessary. As a matter of fact the net strength of the armed forces is now approaching 12 million, and we are producing munitions in a volume not anticipated in 1942.

The data presented by Long also show substantial increases in the American, British and German total labor forces during World War II and he does

not ignore this fact. Apparently, however, his standard of an expansible labor force is ability to replace all civilian workers who are drawn into the armed forces, for in support of his general conclusion he points out that "none of the three countries was able in either war to keep up its civilian labor force from its native population."

The wartime rise in the percentage of the population in the labor force has been approximately the same in the United States as it has been in Britain. In Britain, however, the pre-war worker rate was much higher than in this country so that 70 per cent of the population aged 14–64 were in the labor force at the peak of wartime mobilization in 1942 as compared with only 60 per cent for the United States in late 1943. The higher British worker rate, Long points out, is not a feasible goal for the United States because it reflects two longstanding differences in the social and demographic structures of the two countries, namely, the traditionally smaller percentage of British children over 14 attending school and the smaller percentage of British women with young children to care for.

The fact that the percentage of British women who live in nonfarm areas is much greater than the corresponding percentage for this country also contributes to the higher worker rate found among British women and tends to support Long's conclusion that the differences in labor force participation between the two countries are set deep in their social and economic structures. He does not classify the difference in the farm-nonfarm distribution of the populations as an independent factor, however, because he feels that the lower worker rates found among farm women are merely a reflection of the fact that a much greater proportion have children to care for. But a glance at the returns from the 1940 Census reveals that even when the women with children or women without children are considered separately, the percentage of farm women in the labor force is only about half as great as the corresponding percentage for nonfarm women. In this connection it might be remarked that Long apparently overlooks the effect of increasing urbanization as one of the factors explaining the rise in the percentage of working women in the United States between the two World Wars. He stresses the declining birth rate, which was no doubt the most important factor, and also mentions the lightening of household duties made possible by modern mechanical appliances and the ability to buy goods and services formerly made or performed in the home.

The extra persons who have been drawn into the civilian and military labor force of the United States during the war will, in Long's opinion, most likely drop out at the war's end, leaving the labor force larger than in pre-war days only by reason of population growth. It is reasonable to assume, as Long does, that a large number of young married women will quit work after the war if their husbands can support them. But the older married women have been the chief source of additional adult workers during the war. These women, whose family responsibilities are mostly in the past, have been given their first good job opportunities by the wartime demands

for labor and many of them may wish to continue working when the war is over. Similarly, those older men and marginal workers who were unwilling to expose themselves continuously to the rebuffs of the pre-war labor market, but who are now at work, will remain in the labor force if employment opportunities are favorable when the war is over. On the other hand if post-war employment conditions are generally unfavorable, many of the married women who might otherwise have dropped out of the labor market may be compelled to seek work in order to bolster the family income. All in all it seems more reasonable to assume that perhaps 2–3 million of the 6–7 million extra wartime workers will remain in the labor force during the first year or so after final victory and that 1–2 million will continue in the labor market thereafter. Certainly this is a safer assumption from the standpoint of appraising the magnitude of the post-war employment task.

It would appear from his footnotes that, as a basis for the preparation of this paper, Long has done a detailed analytical job in adjusting decennial Census data for various incomparabilities as well as a painstaking research job in gathering from both primary and secondary sources a great deal of material on population, labor force, school attendance, birth rates, etc. It is unfortunate, however, that a detailed description of the basic data and the estimating procedures has been reserved for later publication because some of the estimates—although they may be perfectly sound—are open to question in the absence of supporting data that can be evaluated by the reader. This is particularly true in the case of the Census adjustments, which conflict with those published by the Census Bureau. For example, Long has *increased* the gainful worker totals for 1910, 1920, and 1930 in order to adjust them for comparability with the labor force as defined in 1940, despite the fact that it is generally agreed that "labor force" is on balance a less inclusive concept than "gainful workers." Only the 1930 gainful worker figures have been adjusted to a labor force base by the Census Bureau and this adjustment involved a net *decrease* of approximately 1,200,000 from the gainful worker total as reported in 1930.

One other case in point is provided by the overcount in the Census of 1910 which was estimated by Long at 1,400,000, but by the Census Bureau at only 800,000. Moreover, Long apparently ignores an undercount of approximately 800,000 in the Census of 1920. This apparent oversight plus the questionable nature of his adjustments greatly weaken his case against the validity of the National Industrial Conference Board's estimates for the period of World War I.

Despite the technical shortcomings and questionable conclusions of this paper, it is significant as a beginning in a field of research which has heretofore been neglected largely because of the lack of adequate data by which to measure short-run changes in the size and composition of the labor force. Since the inception of the sample *Monthly Report on the Labor Force* (initiated in 1940 by WPA and taken over in 1942 by the Census Bureau), it has become possible to study the nature and extent of these short-run changes. As more experience is gained, continued progress should be made toward

appraising the effect of both demographic and economic changes on the size and composition of the labor force.

LEONARD ESKIN

Bureau of Labor Statistics

Wage Determination under Trade Unions, by John T. Dunlop. New York: The Macmillan Company. 1944. ix, 231 pp. $3.50.

The task of evaluating this book is made difficult by the multitude of subsidiary aims encompassed within this "tentative reconnaissance of some of the more prominent and obvious features of the pricing [of labor services] terrain." For this major task, the author has assembled a large array of wage-rate and wage-policy case histories, and has attempted to construct theoretical models of trade union-employer bargaining. These are intended to provide an analytical framework that may be clothed by case histories and institutional studies.

In scrutinizing a vast assemblage of trade union actions and policies, the author has done a competent and useful job. Particularly valuable, in the reviewer's opinion, is the detailed discussion of differences between the bourse-type market assumed by the neo-classical school for all product and factor markets, and the quoted-price market that, in the absence of trade unions, has become characteristic of labor markets in which the large employer hires labor. The function of the trade union, under these conditions, is to change the market into a negotiated price market, thereby in effect restoring a certain amount of competition to a monopsonistic market.

Useful, too, are the discussions of (1) the distinction between short-term impacts and long-term stabilized conditions; (2) the implications of the observed fact that wage rates are set chiefly in terms of the latter, and that neither side to the bargain will customarily press its momentary bargaining advantage to the utmost; (3) the qualification of the term "wage-rate" to correspond, not to a unique and simply-determined magnitude but to a conglomerate of conditions, some of them non-pecuniary, that may be extremely difficult to express in terms of wage-rate levels; (4) the examination of union participation in product markets; (5) the careful distinction between hourly wage-rates and hourly earnings, and the examination of their relative movement in time (useful in relation to the excessive-wage controversies of 1938–40).

Yet all of these points are hardly novel. They have been made, not only by scholars, but also by the unions in their various public statements. What is novel in this book, is an attempt to provide a theoretical (mathematical) model, that can serve to orient discussion of particular cases. Although a good deal of ingenuity has been expended on this effort, the results do not warrant this expenditure.

A theoretical model, if it is to be workable, must abstract from most of the "disturbing" facts, and yet retain an accurate expression of the forces that determine the movement or position of the system. In other words, a

model should delineate the most general features of the area it is intended to describe. Now Mr. Dunlop has chosen for his tools the indifference calculus developed by Alfred Marshall and F. Y. Edgeworth (as distinct from the type recently employed by Bowley, Allen and others). From the assumption of a family of indifference curves for employers and employees, he has derived supply and demand curves for labor, as well as a contract curve that represents the locus of all possible contracts between employers and employees. These families of curves, further modified by specific assumptions, yield relative wage rates under varying degrees and combinations of competition in both product and factor markets, as well as wage rates that will result from a trade union's efforts to maximize a given objective, in this case the total wage bill for a group of workers as defined by the union's membership function.

Marshall's utility calculus, however, was developed for the analysis of static partial-equilibrium states. Mr. Dunlop specifically rejects this approach and claims that his curves may be used to represent a modified general-equilibrium situation. Now such an analysis should (even when limited to clusters of markets) specify the inter-commodity and inter-factor relationships, possibly in the form of a set of simultaneous equations connecting prices and quantities of both factors and commodities. Even more important, if a firm bond is to be established between the model and the real world, it is necessary to prove first that wage bargains are customarily struck in near-equilibrium positions. Yet certainly revisions in wage rates occur most frequently in conditions of rapid change, usually cyclical. Moreover, the study of frictions in the rate of adjustment to new equilibrium positions has demonstrated that lags in the adjustment of supply-demand-price relationships and of the Keynesian propensities, and in general that the failure of expectations to match developments, can easily cause and perpetuate fairly violent oscillations. But most crucial, in the reviewer's opinion, is the neglect, in constructing the theoretical model, of the distinction between voluntary and involuntary unemployment.

In view of the above, it is hardly surprising that the author derives a negatively sloping demand curve for labor—thus implying the inability of trade unions to raise wages except at the expense of employment. Equally certain to follow from hidden premises is the conclusion that perfect competition in all markets will maximize employment. But the contention, qualified to be sure, that workers in monopsonistic industries will enjoy a higher wage than workers in monopolistic industries is rather surprising in the light of the fact that a good many of the sweat-shop industries are or were composed of small producers selling to large buyers. Finally, the series of curves presented in Chapters III and V hide certain assumptions that seem at least peculiar under any specification of a general state. Thus, the unemployment insurance employee-income line, as drawn, seems to imply that any worker is eligible for constant insurance payments for an indefinite period, presumably only by virtue of declaring himself to be a part of the

labor force of the industry, or union membership, at the current wage rate. Lack of space forbids mentioning others.

On balance it is unfortunate that Mr. Dunlop, though keenly aware of the rich diversity of trade union wage-setting activity under actual conditions, should have developed theoretical models that are not only weak in construction, but also yield the type of conclusion that he usually explicitly rejects in other parts of his book.

Jacob Grauman

Washington, D. C.

Gauging Public Opinion, by Hadley Cantril. Princeton: Princeton University Press. 1944. xi, 318 pp. $3.75.

Public opinion polls are likely to become more numerous rather than less. It is said that this field of private enterprise is quite lucrative, especially that part of it that deals with market analyses and consumer preferences. It is also being said that polls can have a great influence in the political field. The examples cited are:

(a) The influence of the National Republican Convention Delegates of the Gallup Polls showing Mr. Dewey's popularity among Republicans, and

(b) The influence among Democrats of the Gallup Poll some months ago showing Mr. Wallace's real popularity as Democratic Vice Presidential candidate among Democrats.

Developments of this sort assure the growth of the polling industry for some time to come in both business and politics. If polls can have even half the influence claimed for them, it is essential that their weaknesses and degree of reliability be more generally understood.

For this reason, *Gauging Public Opinion*, by Professor Hadley Cantril and his research associates will be doubly welcome. Those who are, and are going to be, engaged in the art of interviewing will find this volume extremely useful for both specific technical information as well as general principles.

The five parts of the book deal with problems involved in "setting the issues," problems connected with interviewing, problems in sampling, problems in getting opinion "determinants," and the polling technique applied to a specific problem, namely, the measurement of civilian morale in the United States during the two years before Pearl Harbor and the months following. The last part of the book on our attitudes toward the war and the trends in those attitudes will interest students for many years to come. The rest is a scholarly objective work on the art of public opinion polling, its pitfalls, and "the serious problems encountered in every phase of the polling operation"—a most necessary contribution in a rapidly growing field of activity.

Readers of the book and many others who have heard the Gallup Polls both praised and damned will be interested in the fact that Dr. Gallup has turned the original data of the surveys of his American and British Institutes of Public Opinion over to Professor Cantril for critical analysis. Many of the

studies covered in this volume make use of the Gallup material, as well as the surveys of the Office of Public Opinion Research.

LOUIS H. BEAN

Bureau of the Budget

The Structure of Soviet Wages, by Abram Bergson. Cambridge, Massachusetts: Harvard University Press. 1944. xiv, 255 pp. $3.50.

Professor Bergson has studied the structure of the Soviet Union with a view of determining the degree of wage inequality, and whether the inequality in wages is similar to that existing in capitalist countries. The measure adopted is "the ratio of the workers whose earnings are higher than those of 25 per cent and lower than those of 75 per cent of the workers to the wage of the workers whose position in the frequency distribution is the opposite."

He concludes, after a careful investigation of eight industrial groups, that inequality of wages was less in 1928 than in the pre-revolutionary year of 1914. A reversal in the direction of greater inequality then took place, and in 1934 the inequality in the wages paid different groups of workers in the Soviet Union was greater than 1928. The wage principles used in the Soviet Union are, in his opinion, capitalist principles.

The study is a painstaking investigation with every point carefully documented. While under socialism as well as capitalism relative wages can reflect the attractiveness or disutility of specific types of work, there is still a question of how the basic wage, or the wage from which all others are measured, is calculated. Professor Bergson has not discussed this problem as it perhaps does not fall within the scope of his study. Yet this is an important question in examining the structure of wages; for while wage differentiation may properly reflect the relative valuation placed upon different types of work by labor and administrators, the amount of wages paid may be woefully small as compared with what the economy is able to pay. If the size of the consumption fund for labor, or the part of the real income set aside for the payment of wages, is determined solely by administrative decision, it follows that the administrator can divert arbitrarily any amount of the annual income into nonconsumption, or investment channels, providing the amount were enough to provide for customary standards or even subsistence. There is little in Professor Bergson's study to tell us how wages are set, and by whom; or the role of labor unions and collective bargaining.

In discussing the trend towards inequality, Professor Bergson omits an examination of the political changes and class differentiation that have taken place in the Soviet Union, especially since the defeat of the Trotskyist opposition in 1927. It would be interesting to inquire if increased inequality reflects the rise of a bureaucratic ruling class, less interested in Socialist equalitarianism than were the founding fathers of the revolution.

The question of equality of wage payment under Socialism is touched on

briefly, but the intimation that Socialist writers believe in inequality of wage payment under Socialism does not seem correct. Even the quotation from the *Gotha Program* indicates that Marx believed in equality of payment as an ideal to be ultimately realized in the distant Socialist future. The question therefore arises, why a Socialist society is moving from, rather than towards, these ideals. Perhaps inequality in earnings is a reflection of the disparity in power of the different groups in Soviet society.

Philip Taft

Brown University

Institutions Serving Children, by Howard W. Hopkirk. New York: Russell Sage Foundation. 1944. xiv, 244 pp. $2.00.

The author of this timely volume writes out of years of experience as director of recreation, cottage father, superintendent of an institution for dependent and neglected children, and for a decade as a member of the staff and now Executive Director of the Child Welfare League of America.

The treatment of the historical development of asylums or orphanages into schools and homes for children includes the broader aspects of recent public and private community services for children and a discussion of some of the current programs that have grown out of wartime necessity.

The author points out that lack of consistency in the methods used in the enumeration of children by the Bureau of the Census, in its decennial counts of children in institutions undertaken from 1880 to 1933, limits comparison of various types of services. The data available for the state of New York from 1911 to 1942 are said to show the trend toward use of foster-family homes. The author states that the use of different types of care varies in different states and regions, and that New York as elsewhere is doubtless affected by the program of the assistance to children in their own homes available through the aid to dependent children provisions of the Social Security Act. Nevertheless the number and proportion of children in institutions indicate the continuing importance of this type of care.

A complete section on staff discusses qualifications, training, and working conditions. The brief discussion of the cost of institutional care is of necessity limited by lack of available comparable data.

The major portion of the book is devoted to discussion of those aspects that affect the child most deeply and directly. The chapters on personal relationships of the child and on his education, training, and physical care contain constructive criticism and practical suggestions for the improvement of present standards of care.

The concluding chapter on self-criticism and surveys should stimulate critical evaluation of programs that in many instances is long overdue.

Elsa Castendyck

Children's Bureau
U. S. Department of Labor

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Blair, Morris Myers. *Elementary Statistics, with General Applications.* New York: Henry Holt and Company. 1944. xiv, 690 pp. $3.50.

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Davis, Malvin E. *Industrial Life Insurance in the United States.* New York: McGraw-Hill Book Company, Inc. 1944. xii, 399 pp. $2.75.

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* Annual reports and publications presenting statistics collected at regular intervals have been omitted from this list. Some items of minor interest to statisticians have also been omitted. The contents of periodical publications are not listed, but the attention of the reader is directed to the lists of articles in current publications which are to be found in the *Revue de l'Institut International de Statistique, Journal of the Royal Statistical Society, American Economic Review, Population Index, Transactions of the Actuarial Society of America, The Record of the American Institute of Actuaries,* and *Sankhyā, The Indian Journal of Statistics.*—Editor.

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